

DERMATOLOGIC SURGERY

JONATHAN KANTOR



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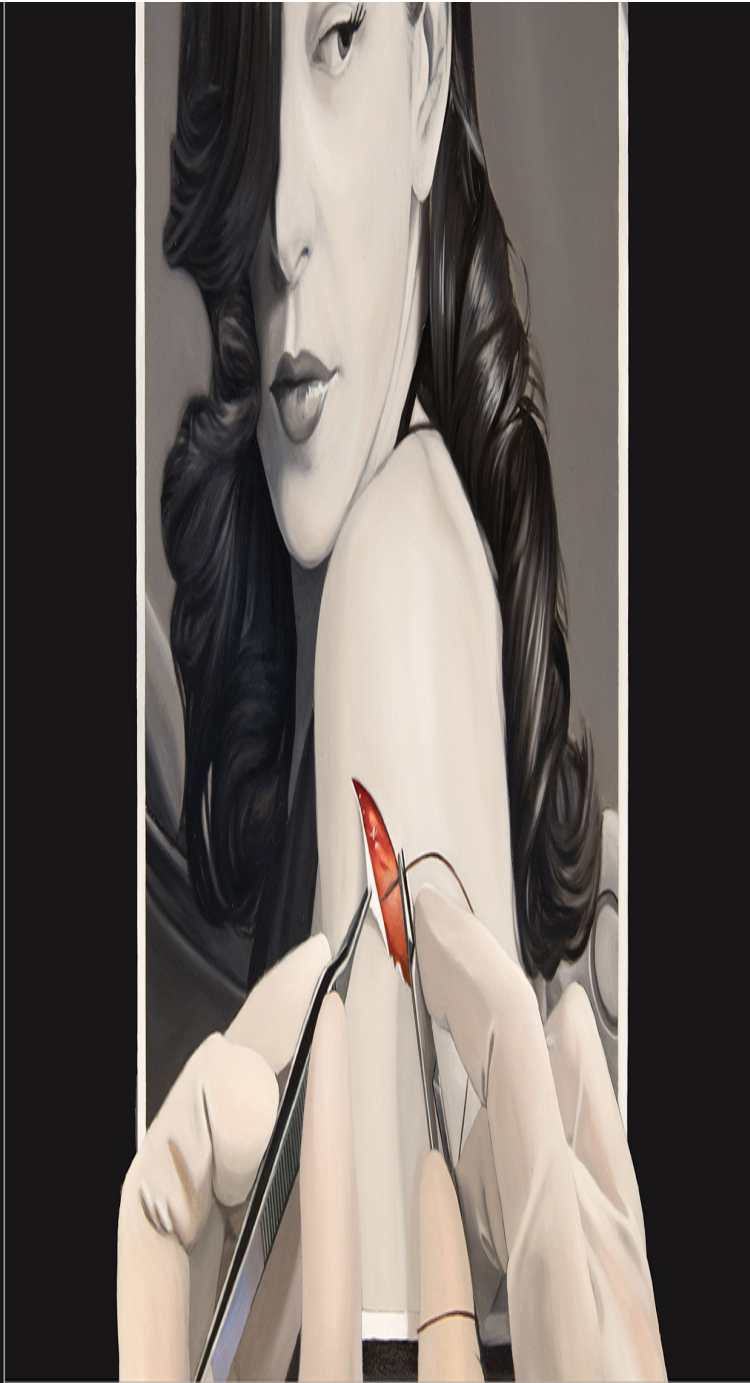


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DERMATOLOGIC SURGERY

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For Bella—passionate partner and problem-solver par excellence.

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Preface

Dermatologic surgery is a young field. During the past four decades, dermatology has pivoted from a primarily medical specialty to an organ-based medical and surgical subspecialty.

Dermatologic surgeons in the United States now not only perform more surgical excisions and linear repairs for skin cancer than all other specialists combined, but the majority of local flaps and grafts as well. At the same time, dermatologic surgeons have wholeheartedly embraced an evidence-based approach to surgical care, and the dramatic expansion in everything from clinical trials to survey studies during the past few decades has been astonishing.

Similarly, aesthetic dermatology has undergone an expansionist trend, with studies suggesting that dermatologists are increasingly seen as the experts of choice for cosmetic procedures.

There are many outstanding dermatologic surgery textbooks both in and out of print, and ideally the reader—whether a budding dermatologic surgeon or a wizened expert—should pore over as many of these as possible.

One of the goals for this text was to produce a book that, at least in rough measure, would reflect the proportion of time, effort, and training required for any given subject. Thus, for example, no fewer than five full chapters (in addition to numerous other sections) are dedicated to Mohs surgery. Similarly, a total of 17 richly illustrated chapters, including those devoted to particular flap techniques and regional approaches to reconstruction, address flap and graft closures, because exposure to a breadth of approaches may be transformative in allowing the trainee to develop a surgical eye. Since anatomy is the foundation on which all surgery is built, the anatomy chapter is centered on a true ground-up cadaveric study of head and neck anatomy with an eye to clinical relevance.

Dermatologic Surgery is, therefore, a bridge text, with the benefits of a single-volume multiauthor global dermatologic surgery textbook coupled with the strengths of a dedicated flap and reconstructive text. It includes not only flap chapters but reconstructive chapters for specific anatomic locations as well. This combination provides both fundamental flap technique didactics and a regional reconstructive approach, which cements the breadth of reconstructive options available to the dermatologic surgeon.

Diversity in dermatology is important, not only for surgeons, but for patients as well. Thus, this text includes a chapter focused on ethnic and gender differences in filler use, a chapter on laser use in skin of color, and a detailed chapter on the burgeoning field of female genital rejuvenation. The world of dermatologic surgery is changing rapidly, and therefore chapters on ethics, billing and financial considerations, clinical research, radiation therapy, body contouring, and others have been included. Cosmetic dermatologic surgery is a rapidly evolving field; therefore, this text takes a real-world approach to the use of fillers and neuromodulators, since the majority of their use in dermatologic surgery is outside of the narrow confines of FDA-approved indications.

By devoting special sections to surgical treatments by disease state for everything from melanoma and dysplastic nevi to hidradenitis and vitiligo, both a forward- and backward-referencing capability are added. Similarly, for cosmetic treatments, the book includes chapters that are centered not only on a given treatment (vascular lasers, dermabrasion, or fillers) but also by condition or concern, so that the reader can learn approaches both from the ground up and in a natural didactic fashion based on the patient's presenting concerns.

Full-length high-quality videos are an essential adjunct to learning procedural techniques, and this text is accompanied by the largest video resource of its kind ever compiled. This resource, coupled with close to 3,000 high-quality clinical photographs and nearly 500 professional medical illustrations, including infographics with surgical pearls for each chapter—with many pearls stratified by beginner tips, expert tips, cautions, patient education points, and even billing tips—help make this text truly unique.

Finally, this text is the first of its kind to include a chapter dedicated solely to laser treatment for burns and trauma. This chapter should serve as a resource and inspiration for clinicians eager to help those who may stand to benefit the most from some of the techniques discussed throughout this book.

I am honored to have an all-star cast of section editors who helped with recruiting chapter authors. These section editors include prominent academic and private-practice dermatologic surgeons who, among other honors, have served as president of the American Board of Dermatology, president of the American College of Mohs Surgery (two of the section editors), president of the American Society for Dermatologic Surgery, and editor in chief of the *Dermatologic Surgery* journal.

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Chapter 22: Figure 22-4.

Chapter 23: Figures 23-7, 23-8, 23-13, and 23-18.

Chapter 27: Figure 27-1.

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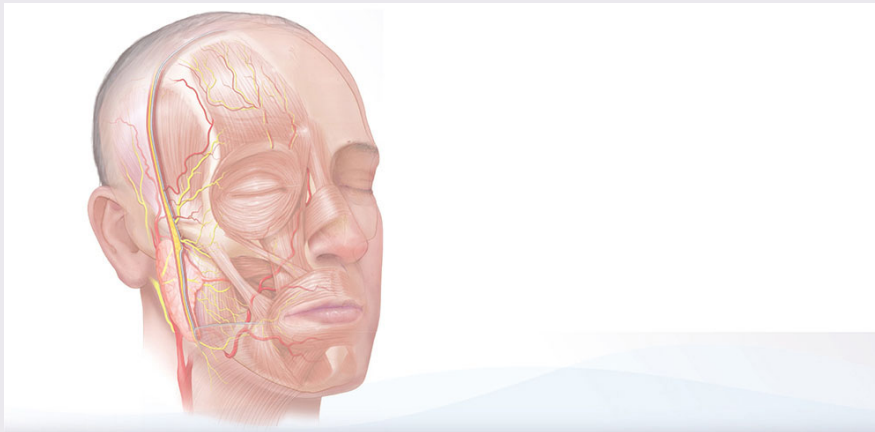
Part I

FUNDAMENTALS

- 1 Surgical Anatomy, Surface Anatomy, and Cosmetic Subunits
- 2 Wound Healing and Surgical Wound Dressings
- 3 Preoperative Evaluation, Patient Preparation, and Informed Consent
- 4 The Surgical Suite
- 5 Surgical Instrument Selection
- 6 Suture Materials and Needles
- 7 Antibiotics: Preoperative and Postoperative Considerations
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- 9 Ethics in Dermatologic Surgery
- 10 Billing and Financial Considerations in Dermatologic Surgery
- 11 Clinical Research in Dermatologic Surgery

CHAPTER 1 Surgical Anatomy, Surface Anatomy, and Cosmetic Subunits

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SUMMARY

- Conceptualizing superficial anatomy as a three-dimensional-layered system helps understand the course and location of important neurovascular structures as they travel in a stepwise pattern in and between the muscular, bony and fascial planes to reach their terminal areas of supply and innervation.
- When approaching anatomically susceptible regions (“danger zones”), understanding the depth, course, and relation of these structures as they traverse anatomical boundaries provides the key to successful surgery.

Beginner Pearls



- Striated muscles of the face (muscles of facial expression) produce movement of the overlying soft tissue by creating tension transmitted by fibrous strands (retinacula) that connect the SMAS to the skin.
- Facial nerve branches, while generally protected by the SMAS, are surgically vulnerable as they reach areas of transition along their course toward their final destination.
- The forehead and temple are functionally related to the scalp, and through SMAS can easily glide over the skull.

Expert Pearls



- The internal carotid artery via its ophthalmic branch supplies a central triangular area including the eyes, superior nose, and central portion of the forehead.
- The angular artery and vein cross the medial canthal tendon and contribute to an important site of anastomosis just superior to the tendon between branches of the external carotid (facial artery) and internal carotid (ophthalmic artery).
- Nasal blood supply is mainly from the angular artery externally and the sphenopalatine artery internally, with smaller contributions from the superior labial and ophthalmic arteries.
- The parotid gland is contained within a shiny, tight fascial sheath (the parotid fascia), which helps differentiate it from fat.

Don't Forget!



- The key area of anastomosis between the external and internal carotid arteries is located above the medial canthal tendon where the angular artery communicates with the dorsal nasal branch of the ophthalmic artery.
- Both the facial artery and the marginal branch of the facial nerve lie deep to the fibers of the platysma.

Pitfalls and Cautions



- Erb's point, located 6 cm below the midpoint of a line connecting the angle of the mandible with the mastoid process, provides a landmark for the exit point of the superficial cervical nerves and the accessory nerve (cranial nerve XI).
- The mandibular branch of the facial nerve crosses over the facial artery about 5 to 10 mm above the point at which the facial artery crosses the mandible.

CHAPTER 1 Surgical Anatomy, Surface Anatomy, and Cosmetic Subunits

INTRODUCTION

Successful surgical reconstruction of the skin and soft tissues involves an understanding of the architecture of the superficial face and how to maintain its natural anatomy following surgical manipulation. Anatomically, the superficial face displays significant variation in skin thickness, texture, color, subcutaneous fat, and laxity.

Naturally occurring lines divide the face into demarcated areas referred to as cosmetic units. As these cosmetic units tend to display anatomical homogeneity, surgical repair for ideal cosmetic outcome should be based on preservation of the subunits by maintaining incision lines along or within natural contour lines. Cosmetic units are demarcated by contour lines that divide the face anteriorly into the (1) forehead, (2) nose, (3) cheeks, (4) eyes, and (5) lip. Anterolaterally, contour lines bound the (6) cheeks and laterally the (7) ears. Each of these areas is then divided into subunits.

The description of the anatomy is based on visualization of structures as they travel from one anatomical plane to another along their course and distribution. It is important to keep in perspective the changing relationships that exist between the fascial, superficial, and deep muscle layers and the important traversing neurovascular structures. As these relationships are mostly predictable, a thorough understanding of the underlying anatomy within the operative field limits hesitation and improves surgical confidence.

KEY PRINCIPLES FOR UNDERSTANDING FACIAL ANATOMY

Relaxed skin tension lines of the face

Striated muscles of the face (muscles of facial expression) produce the movement of the overlying soft tissue by creating tension transmitted by fibrous strands (retinacula) that connect the superficial musculoaponeurotic system (SMAS) to the skin. In younger individuals, this tension is opposed by elastic fibers within the skin. With progressive aging, however, changes in the configuration of collagen fibers and the decreased ability of the elastic fibers to resist this tension result in the formation of wrinkle lines along these retinacula attachments. Relaxed skin tension lines (RSTLs), therefore, run perpendicular to the underlying muscle fibers; for example, wrinkle lines on the forehead run horizontally since the frontalis muscle contracts vertically.

Understanding the profiles of RSTLs is a key element in surgical planning with the goal of minimizing visible scarring. Techniques for scar reduction have been well described in the literature, and one principle is to align the long axis of the repair within or as close as possible to the RSTL to promote merging of the scar into the wrinkle line. While RSTLs are typically more pronounced and easily identifiable in elderly patients, the application of the anatomical arrangement of the underlying muscle fibers and its directional relationship to the fibrous septa is helpful in accentuating RSTLs when not easily identifiable. Therefore, having patients perform exaggerated facial expressions will expose these lines, while gentle manipulation of the skin may also highlight RSTLs (Fig. 1-1).

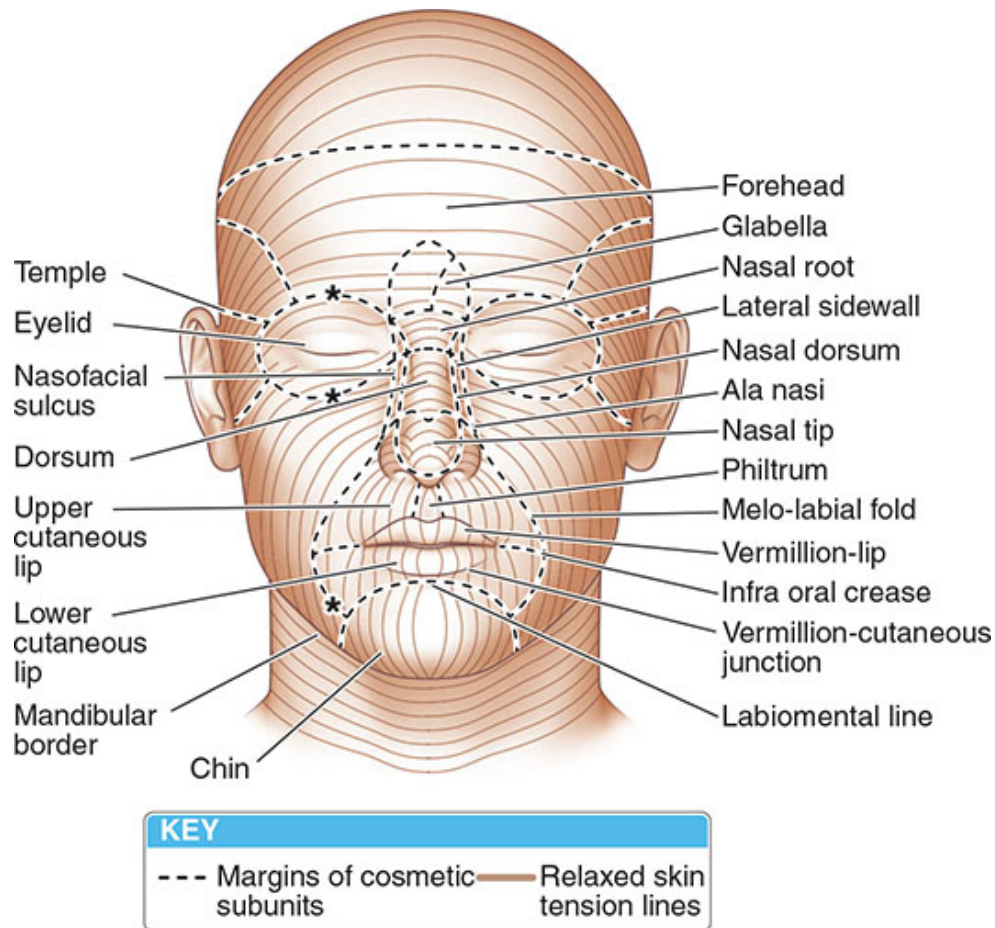


Figure 1-1. Diagram illustrating cosmetic subunit boundaries and relaxed skin tension lines.

UNDERSTANDING THE FASCIAL PLANES OF THE FACE AND NECK

The anatomy of the face and its subunits presents itself through a distinct arrangement of fascial planes that enclose subcutaneous tissue, superficial muscles, nerves, and blood vessels. Deconstructing the complex relationships that exist between these planes provides a view of the course and relations of vascular networks and important traversing branches of the superficial motor and sensory nerves. Understanding and predicting the trajectory of the branches of an intricate plexus of motor and sensory nerves within the muscular architecture is crucial to minimizing complications associated with dermatologic surgery.

A few basic concepts are strategic to predicting potential challenges that accompany surgical manipulation of the superficial face:

1. The face can be dissected through principle fascial planes that consist of skin, subcutaneous fibroadipose layer, SMAS, space containing traversing nerves and retaining ligaments, and deep fascial layer (Fig. 1-2).^{1,2}

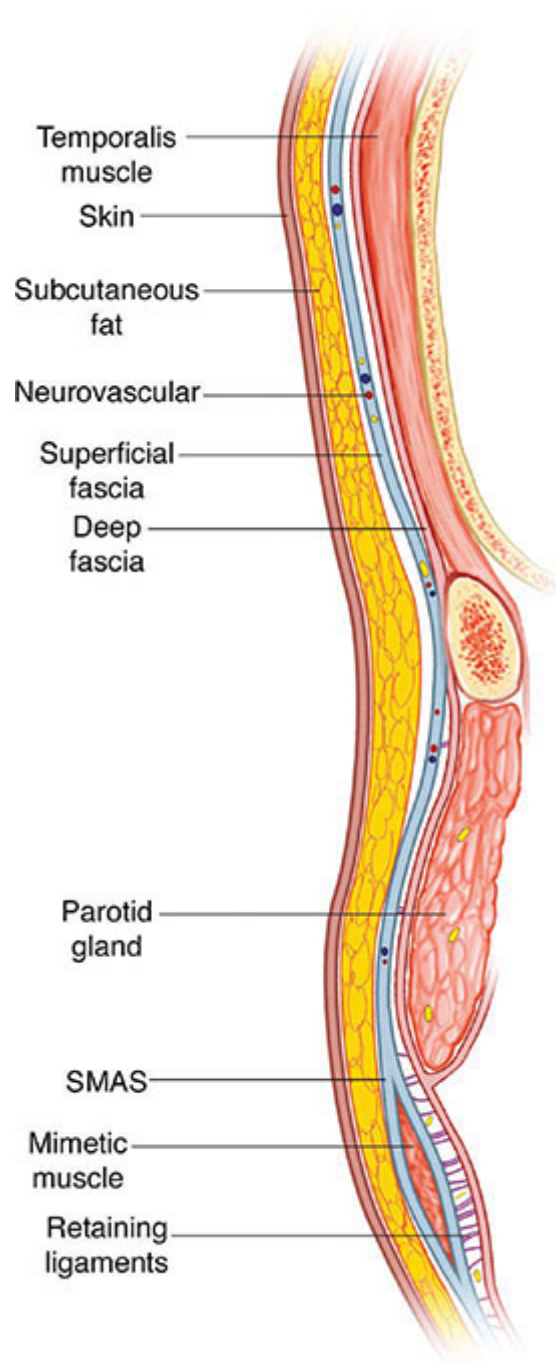


Figure 1-2. Conceptual illustration demonstrating layers of the face from superficial to deep. (By permission of Mayo Foundation for Medical Education and Research. All rights reserved).

2. Muscles of facial expression are not set within the same architectural plane. They are attached to the dermis and are reinforced by retaining

ligaments while maintaining an arrangement within a stepped configuration (Fig. 1-3).²

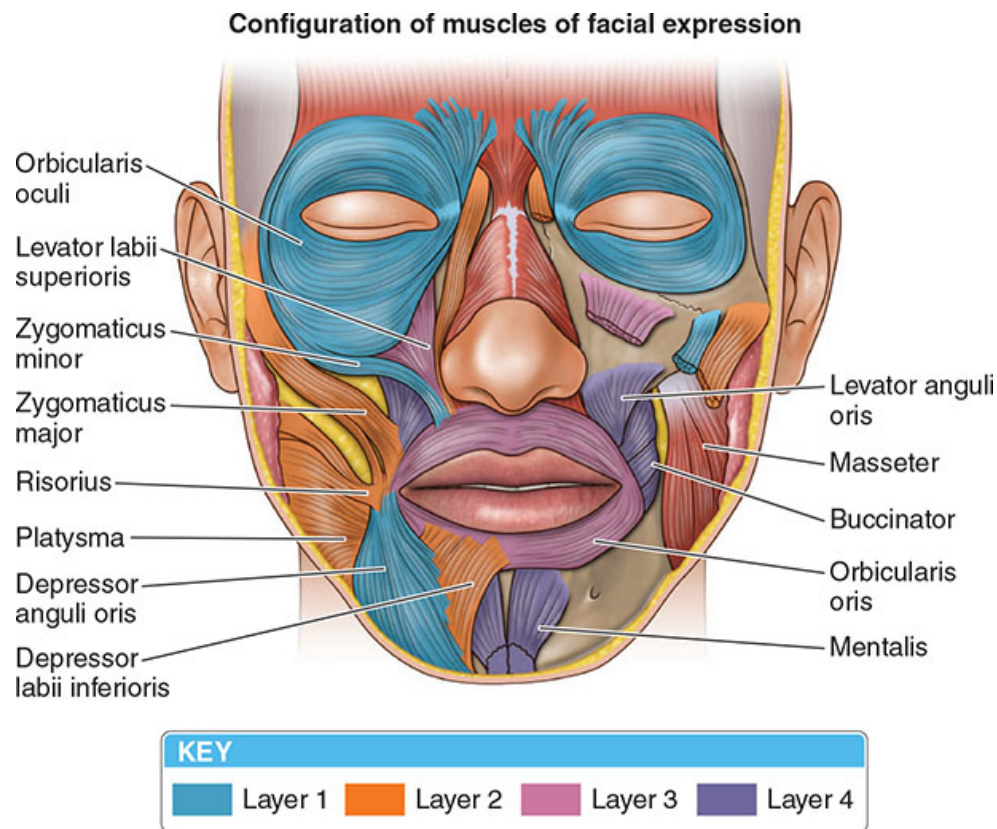


Figure 1-3. Diagram illustrating stepped configuration and arrangement of muscles of facial expression (mimetic muscles).

3. Exiting branches of the facial nerve are the principal motor suppliers of the muscles of facial expression and they tend to innervate these muscles through their deep surfaces, overlying muscles only as they traverse from their points of origin to innervation (Fig. 1-4).^{3,4}

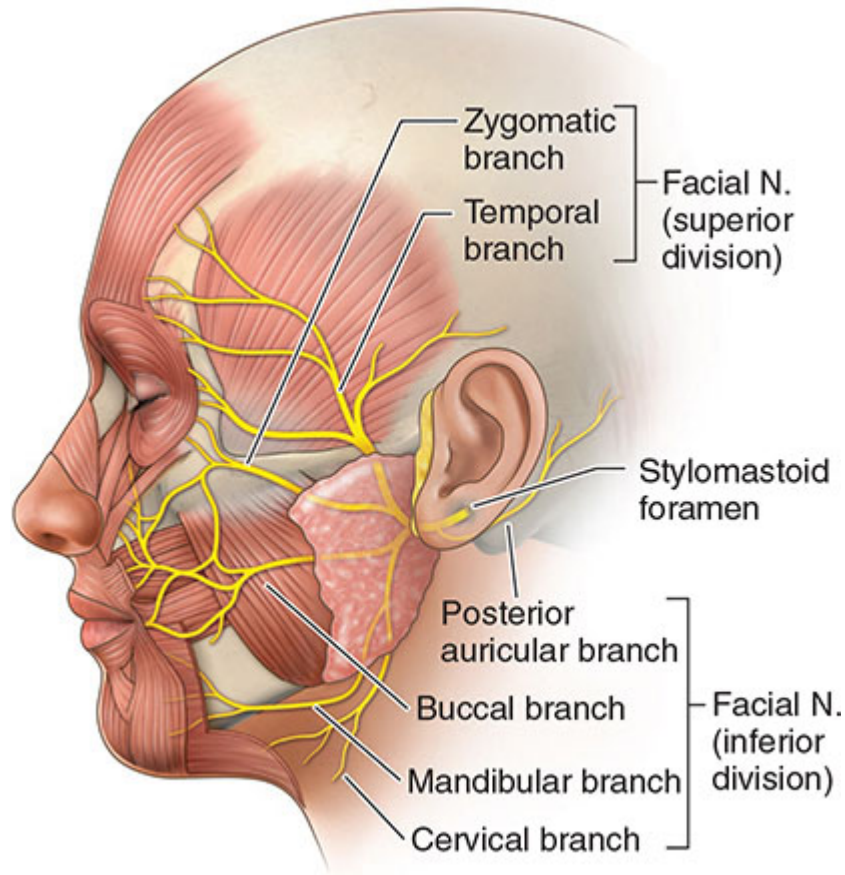


Figure 1-4. Diagram illustrating standard pattern of distribution of branches of the facial nerve.

4. Facial nerve branches exit the parotid fascia along its anterior margin, often networking as they travel from a deep to superficial plane, while still lying deep to the SMAS plane (Fig. 1-5).⁵

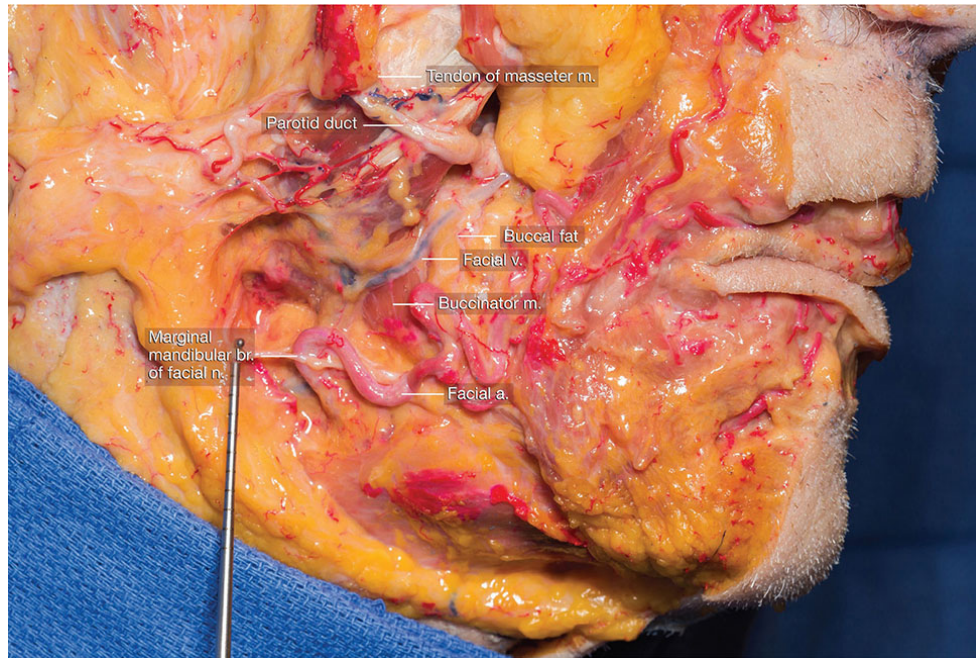


Figure 1-5. Deep dissection of facial nerve with reflected upper portion of parotid gland.

5. Facial nerve branches divide into a variable number of rami, and in the mid-lateral face form a plexus of interconnected communications including connections between the facial nerve and the trigeminal nerve branches (Fig. 1-6).^{5,6}

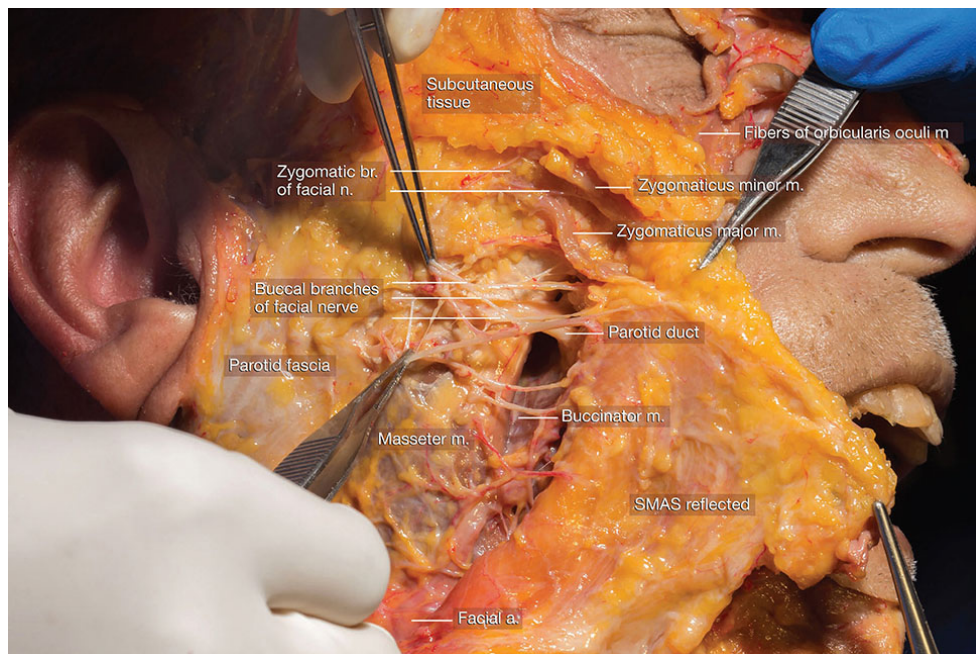


Figure 1-6. Dissection of facial nerve deep to SMAS.

6. While the SMAS splits to enclose muscles of facial expression, it remains continuous with fascia of the platysma, superficial parotid fascia, galea aponeurotica, and superficial temporal fascia (temporoparietal fascia) (Fig. 1-2).⁷
7. While the superficial temporal vessels are contained within the SMAS, the sub-SMAS plane remains relatively avascular (Fig. 1-7).⁷

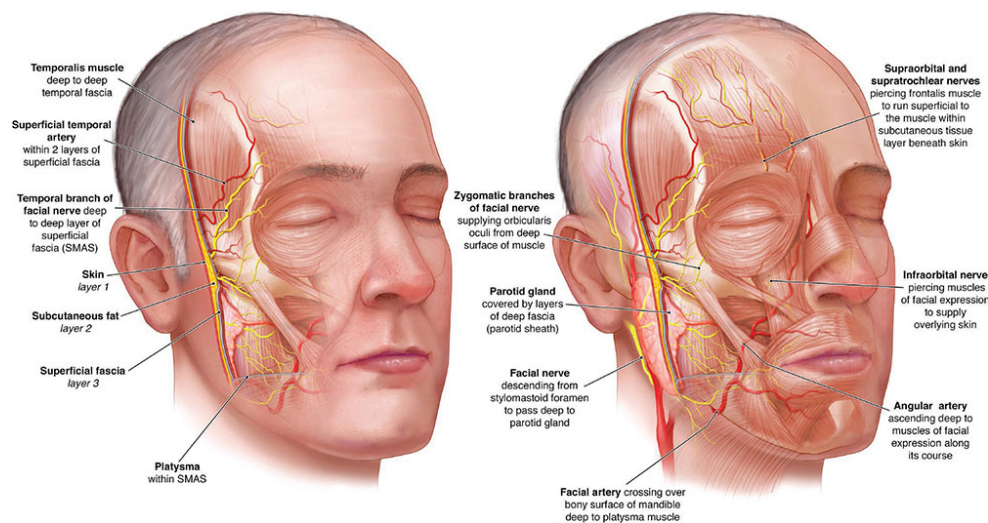


Figure 1-7. Conceptual illustration demonstrating relationship of structures within layers of the face from superficial to deep. (By permission of Mayo Foundation for Medical Education and Research. All rights reserved).

8. Trigeminal nerve branches travel in a plane above the SMAS and then exit the supraorbital, infraorbital, and mental foramina, and travel in a deep to superficial direction toward the skin, where they lie within the subcutaneous fibro-adipose layer (Fig. 1-8).^{4,8-10}

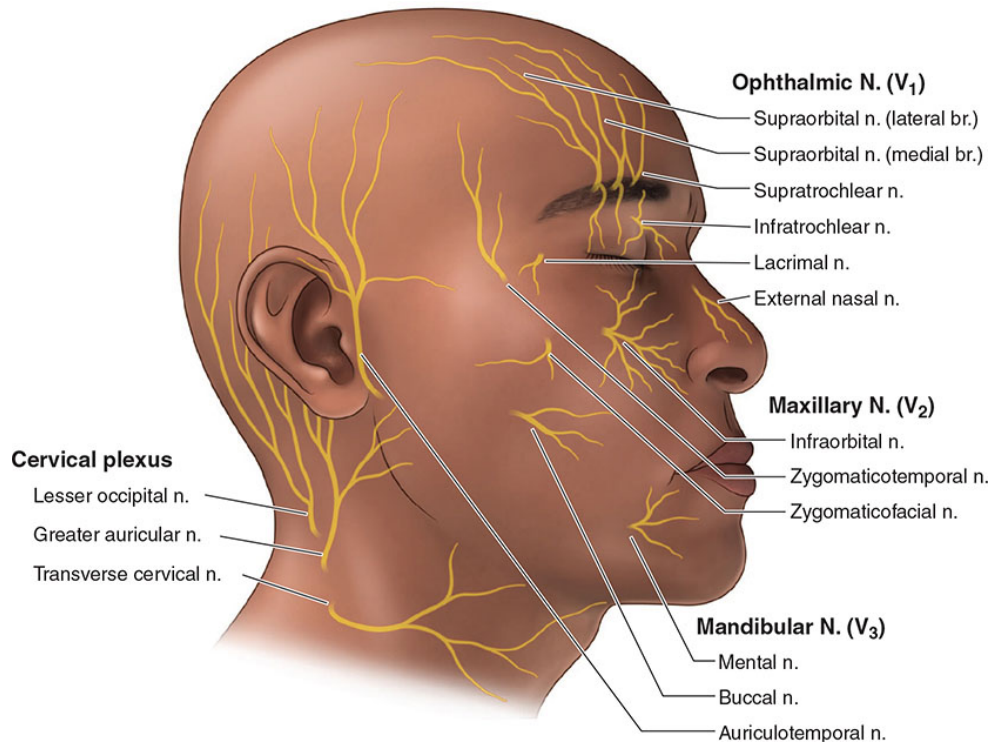


Figure 1-8. Diagram illustrating distribution patterns of sensory branches of the trigeminal nerve.

9. The facial artery and its branches travel deep to the SMAS and run along a superficial course to cross palpable bony boundaries or penetrate the SMAS (Fig. 1-7).^{11,12}
10. The thickness of the subcutaneous layer varies significantly and displays fat compartments that are predictable and distinct within cosmetic subunits. The layer is more uniform in thickness over the scalp, while compaction of the subcutaneous tissue around the eyelids and lips appears to make this layer almost nonexistent.^{1,2,13,14}

Concept of the superficial musculoaponeurotic system

The concept of the SMAS is best understood by looking at the SMAS as a single continuous layer of organized fibrous network that divides at predictable locations in order to enclose the muscles of facial expression and keep them connected to the dermis.

Histologically, SMAS is described as a three-dimensional (3D) architecture of collagen, elastic fibers, adipose, and muscle tissue.^{2,4,7,15} Typically, the arrangement of SMAS determines the flexibility of the overlying structures. For example, SMAS can exhibit a meshwork of fibrous septa that envelops lobules of fat within an interconnecting fibrous network¹⁵ connected to facial muscles or periosteum. This type of arrangement is best demonstrated in the forehead; parotid, zygomatic, infraorbital regions; and lateral nasolabial fold.¹⁵

Alternately, in and around the upper and lower lip regions, SMAS exhibits an intermingling arrangement of collagen, muscles, and elastic fibers extending up to the dermis. Around these areas, single adipocytes, rather than adipose tissue accumulations (compartments), are interposed between the fibers. These regions represent highly innervated areas where numerous sensory nerve branches may be encountered during microscopic visualization.⁷

With regard to SMAS and its relationship with deeper investing fascia, two important points can be made about the fascia associated with temporalis muscle and the fascia associated with the masseter muscle. (1) As the temporalis muscle arises from the superior temporal line and the floor of the temporal fossa, it fans out to pass medially to the zygomatic arch and inserts onto the coronoid process and anterior border of the ramus of the mandible.¹⁶⁻¹⁸ A dense layer of deep fascia overlies the superficial surface of the muscle and is referred to as the *deep temporal fascia* which extends superiorly to attach to the superior temporal line. Deep temporal fascia is overlapped by the auricularis muscle anteriorly and superiorly by the epicranial aponeurosis and part of orbicularis oculi muscle.^{4,9}

In a region above the zygomatic arch, on the lateral aspect of the head, fascia continuous with the SMAS is separated from the temporal fascia by a layer of loose connective tissue with some adipose tissue and is commonly referred to as the *superficial temporal* or *temporoparietal fascia*. Within its two layers, the temporoparietal fascia^{11,16,19} contains the superficial temporal vessels,¹⁷ auriculotemporal nerve, and temporal branches of the facial nerve en route to the frontalis and portions of the orbicularis oculi muscles (Figs. 1-2 and 1-7).

(2) The deep fascia of the masseter muscle is intimately connected to the deep layer of the parotid capsule. As the deep investing fascia divides to

enclose the parotid gland, it is connected to the masseteric fascia and is often seen as a composite parotid–masseteric fascia.^{4,9} This close association between the fascial layers is mostly unyielding and does not provide easy access to a surgical plane. The superficial layer of the parotid fascia is continuous once again with the SMAS.

Topographic framework of the superficial face

The five-layer construct typically associated with the scalp can be applied in understanding the fascial framework of the face.² Most superficially, the first layer is the skin, with its epidermis and underlying dermis (Layer 1) varying in thickness, density, and regional conformation.² The subcutaneous plane (Layer 2) contains volume-defining adipose tissue and a fibrous “retinacular cutis” which is composed of dense irregular connective tissue characterized by thick, irregular bundles of mostly type I collagen and elastic fibers.²⁰ The reticular layer contains portions of retaining ligaments that traverse through the subcutaneous tissue (varying regional density) connecting the dermis to the SMAS.^{1,7}

The SMAS layer (Layer 3) is continuous over the entire face. The muscles of facial expression are contained within the composite superficial fascia (Layers 1–3) and lie within this layer, followed by deeper set muscles providing more functional roles (e.g., orbicularis oculi, orbicularis oris).^{7,15,16,21} Layer 3 reflects the galea aponeurotica of the scalp, superficial temporal fascia over the temporal region, orbicularis fascia in the orbital area, SMAS over the inferior face (mid and lower), and the platysma in the neck.¹⁵

Layer 4 consists of soft tissue spaces, facial ligaments, deep portions of the muscles of facial expression, and segments of the facial nerve branches traversing toward points of innervation.^{1,2} On the lateral face, anterior to the ear and extending down toward the posterior border of platysma, the superficial fascia fuses with the deep fascia (fibrous capsule of parotid gland), creating a tightly bound composite of Layers 1 to 5 thereby reducing Layer 4 to an undissectable plane (Fig. 1-2).²

Layer 5 is formed by the deep fascia overlying the superficial muscles of mastication (deep temporal fascia, masseteric fascia), by the periosteum

covering the bone, and the parotid fascia forming the unyielding fibrous capsule of the parotid gland (Figs. 1-2 and 1-7).^{1,2,9,15}

Surgically relevant anatomy within cosmetic units

In addition to Salasche et al.'s²² detailed and insightful account of the anatomy related to the surgery of the skin, recent research has added to the understanding of key anatomical concepts regarding dermatologic surgery within cosmetic units.^{23,24} The ensuing discussion of relevant anatomy has been built on the anatomy encountered during superficial dissection within these territories along with well-established reviews and current literature.

Forehead

- Muscles acting on the forehead and eyebrow: frontalis, corrugator supercilii, and procerus.
- The forehead and temple are functionally related to the scalp and through SMAS can easily glide over the skull.
- The supraorbital and supratrochlear neurovascular bundles supply this region.

The forehead extends from the hairline to the eyebrows in a vertical direction and ends laterally at the temporal ridges. Skin of the forehead varies in dermal thickness, decreasing as it extends superiorly toward the hairline. Additionally, while more taut in younger individuals, the skin of the forehead in older patients tends to be more mobile, usually as a result of chronological or actinic damage. Beneath the skin, the subcutaneous layer is minimal, usually not more than about 1 mm thick. Just deep to the subcutaneous tissue, the SMAS encloses the frontal or anterior belly of the occipitofrontalis muscle with its vertically oriented fibers. As the thickness of the muscle tends to decrease with age, these fibers can be rather sparse in older patients, making the traversing neurovascular structures easier to reach.

Between the left and right anterior bellies of occipitofrontalis, a fascial extension known as the galeal median raphe is present. The galeal raphe is devoid of muscle fibers and does not usually contain any significant

associated neurovascular structures. Inferiorly, superolateral fibers of the orbicularis oculi can be visualized as they interface with the medially located fibers of procerus and corrugator supercilii.

It is helpful to remember that the frontalis muscle is enveloped by superficial and deep investing layer of the SMAS and periosteum. The supratrochlear and supraorbital nerves are important structures that provide sensory innervation to the scalp and skin. They exit the supraorbital foramen within a neurovascular bundle above the orbital rim (Fig. 1-9). Christensen et al.²⁵ described the origin and depth of the supraorbital nerve. The neurovascular bundle originates an average of 26 mm from the midline and is 7.5 mm deep at its origin beneath the corrugator supercilii muscle, continuing superficially above frontalis muscle.



Figure 1-9. Anterior view of dissection of the upper face highlighting supratrochlear and supraorbital nerves.

The forehead receives vascular supply centrally from the right and left supratrochlear and supraorbital arteries and bilaterally by the anterior branch of the temporal arteries. These vessels are located in the subcutaneous tissue and are predictable in their location. The supratrochlear artery serves as the basis of the axial paramedian forehead flap (Fig. 1-10), and therefore knowing that the origin of the neurovascular bundle is approximately 13 mm

from the midline, in line with the medial canthus, may be helpful. Furthermore, the neurovascular bundle originates above the brow from the supraorbital foramen and is initially deep to the corrugator supercilii and above the periosteum. The bundle courses through the corrugator supercilii, initially deep to the frontalis, but as they move superiorly they branch and become more superficial, piercing the SMAS and coursing through the frontalis to reach the subcutaneous tissue (Fig. 1-11). Details of arterial diameter, depth, and branching patterns of the superficial temporal artery have been extensively described,²⁶ averaging 2 mm in diameter at a depth of 1 to 2 mm and with an average of nine visible branches. Rich collateral circulation of the forehead skin supports the use of random pattern cutaneous flaps.

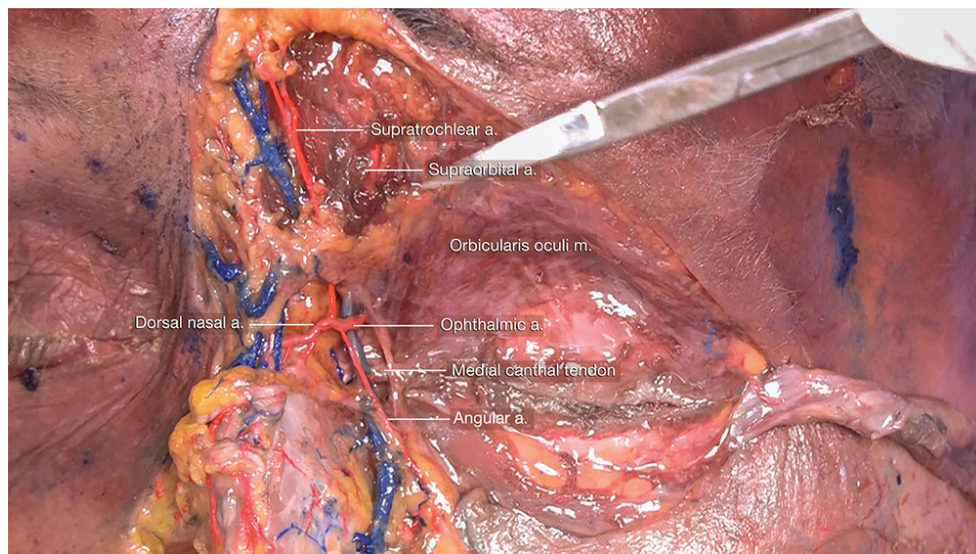


Figure 1-10. Anatomy of anastomosis around the medial canthus of the left eye.

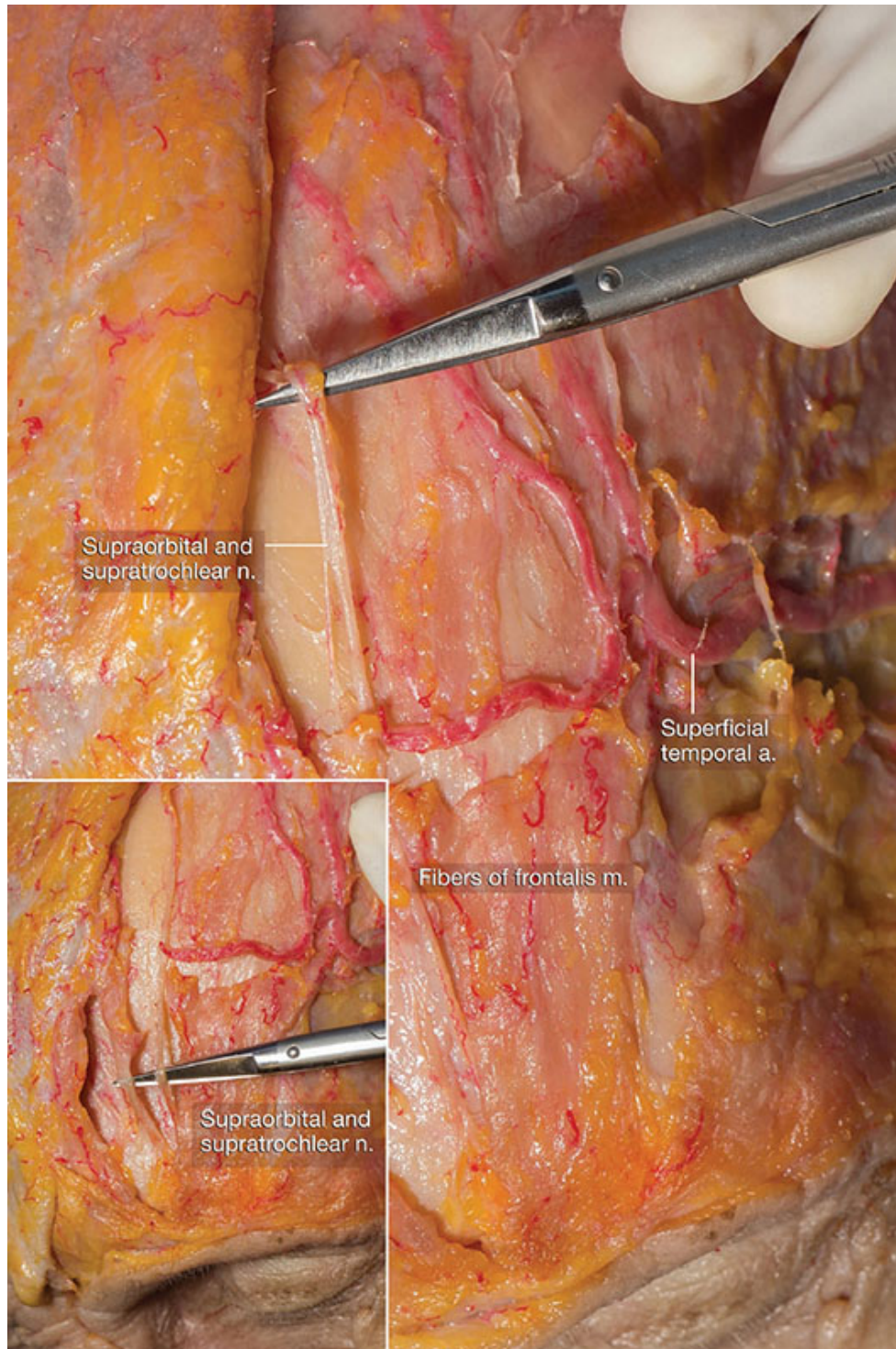


Figure 1-11. Supraorbital and supratrochlear nerves coursing over fibers of frontalis muscle.

Temple

- The superficial temporal artery travels within the layers of the superficial temporal fascia.
- Rich anastomosis occurs between branches of the superficial temporal artery and supraorbital artery.
- The auriculotemporal nerve runs deep and posterior to the superficial temporal artery.
- The frontal branch of the facial nerve is most vulnerable as it crosses the zygomatic arch as a single trunk en route to the deep surfaces of the frontalis muscle.

The temporal fossa contains a relatively sparse amount of subcutaneous tissue devoid of muscles of facial expression, with the exception of traversing fibers of the orbicularis oculi muscle and even fewer fibers of the anterior auricular muscle. Two distinct layers of fascia are contained within this unit. The deep temporal fascia, which is a continuation of the investing fascia containing the deeper temporalis muscle as it becomes continuous with the periosteum of the skull; and the superficial temporal fascia, which is a continuation of the SMAS as it connects to the galea aponeurotica (Fig. 1-12). In this region, the superficial temporal fascia is of anatomical and subsequent surgical importance as it contains within its layers key vascular and neural structures as they traverse between the fascial layers. The superficial temporal artery along with its branches and sensory nerves, including the auriculotemporal nerve, can be accessed within the layers of the superficial temporal fascia (Fig. 1-12). The motor branches of the facial nerve remain deep to the superficial temporal fascia as they course toward the deep surface of the orbicularis oculi and frontalis muscles (Fig. 1-6). The superficial temporal fascia forms a continuous layer with the galea aponeurotica, but splits medially to enclose the frontalis and orbicularis oculi muscles and laterally the superficial periauricular fibers. Inferiorly, the superficial temporal fascia is adherent to the zygomatic arch. Immediately adjacent to the superficial layer of the superficial temporal fascia, the subcutaneous fatty layer separates it from the overlying dermis. Fibrous septa create a more taut area as one moves toward the scalp, with relatively greater laxity just above the zygomatic arch. Numerous cutaneous vessels and nerves lie in this interval between the fat and fascia, which is important to remember when undermining in this area. The deep layer of the superficial

temporal fascia glides over the loose connective tissue of the deep temporal fascia, deep to which the temporalis muscle can be visualized (Fig. 1-12).

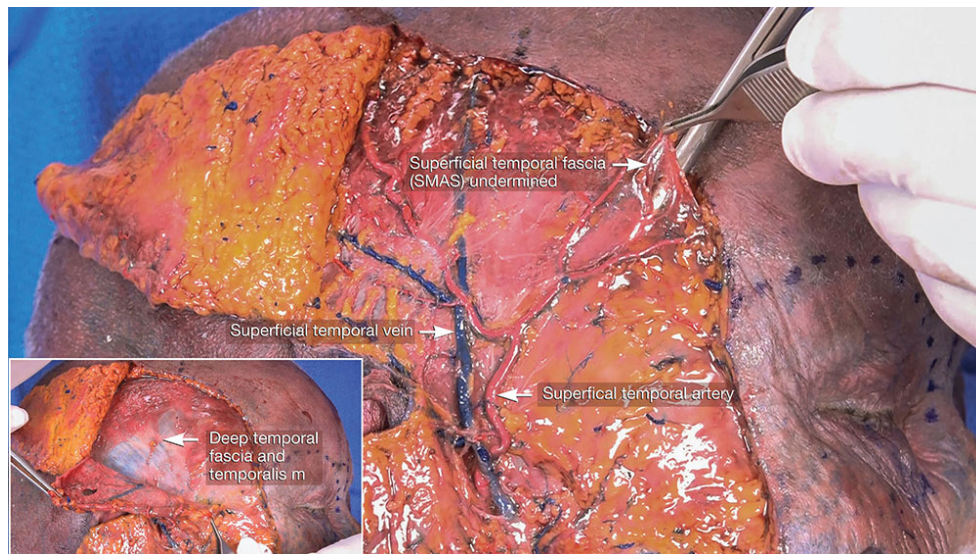


Figure 1-12. Dissection of superficial temporal fascia reflected to show superficial temporal vessels.

The primary source of vascular supply to the temple comes from the superficial temporal artery, a terminal branch of the external carotid artery. The superficial temporal artery emerges from the superior pole of the parotid gland as it pierces the parotid fascia anterior to the tragus (Fig. 1-12). Inferior to it, the transverse facial artery runs below and in line with the zygomatic arch. The artery is accompanied by the corresponding veins, and usually divides anteriorly into anterior and posterior branches, with two or sometimes three significant sized pedicles. The anterior branch follows a distinct tortuous course, especially prominent in elderly patients, to supply the temple and the temporal scalp region. Branches anastomose freely with the posterior parietal branches as well as contributions from the supraorbital artery. From an anatomical standpoint, it is important to note that while the superficial temporal artery lies within the layers of the superficial temporal fascia, the corresponding veins are located within the subcutaneous layer. As the arteries continue toward the scalp, they also come to lie within the subcutaneous plane just above the superficial temporal fascia.

Sensory innervation to the temple is achieved via the maxillary and mandibular divisions of the trigeminal nerve. The auriculotemporal nerve (Fig. 1-13) travels posterior and deep to the superficial temporal artery and

branches as it runs within the same fascial plane as the artery as they proceed toward the scalp. The skin adjacent to the lateral canthus is supplied by a branch of the maxillary artery, with the zygomaticotemporal nerve emerging from the lateral orbital wall. Additionally, the zygomaticotemporal nerve innervates an area of scalp between the territories of the auriculotemporal and supraorbital nerves (Fig. 1-8). Emerging from the superior pole of the parotid gland, the temporal branch of the facial nerve crosses superficial to the zygomatic arch as a single branch within the superficial temporal fascia increasing its vulnerability to surgical injury (Fig. 1-14). With the use of surface anatomical landmarks, the temporal branch may be visualized along a line 0.5 cm below the tragus to a point approximately 1.5 cm superior to the lateral edge of the eyebrow. The temporal branch of the facial nerve supplies the frontalis muscle from the deep lateral edge with few branches contributing to fibers of orbicularis oculi and those of surrounding muscles of facial expression.

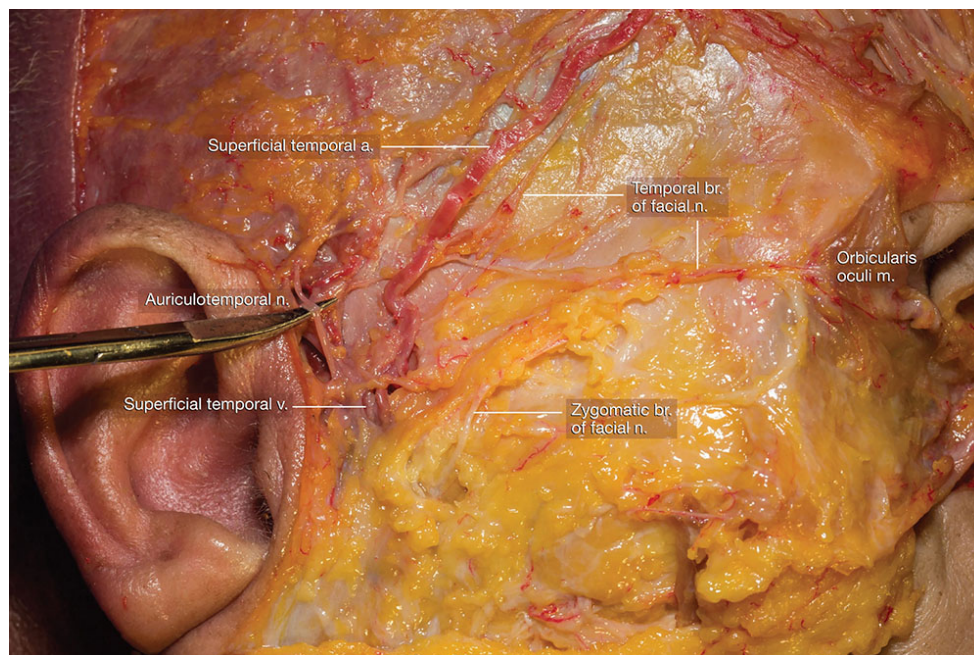


Figure 1-13. Dissection of temporal region highlighting the auriculotemporal nerve.

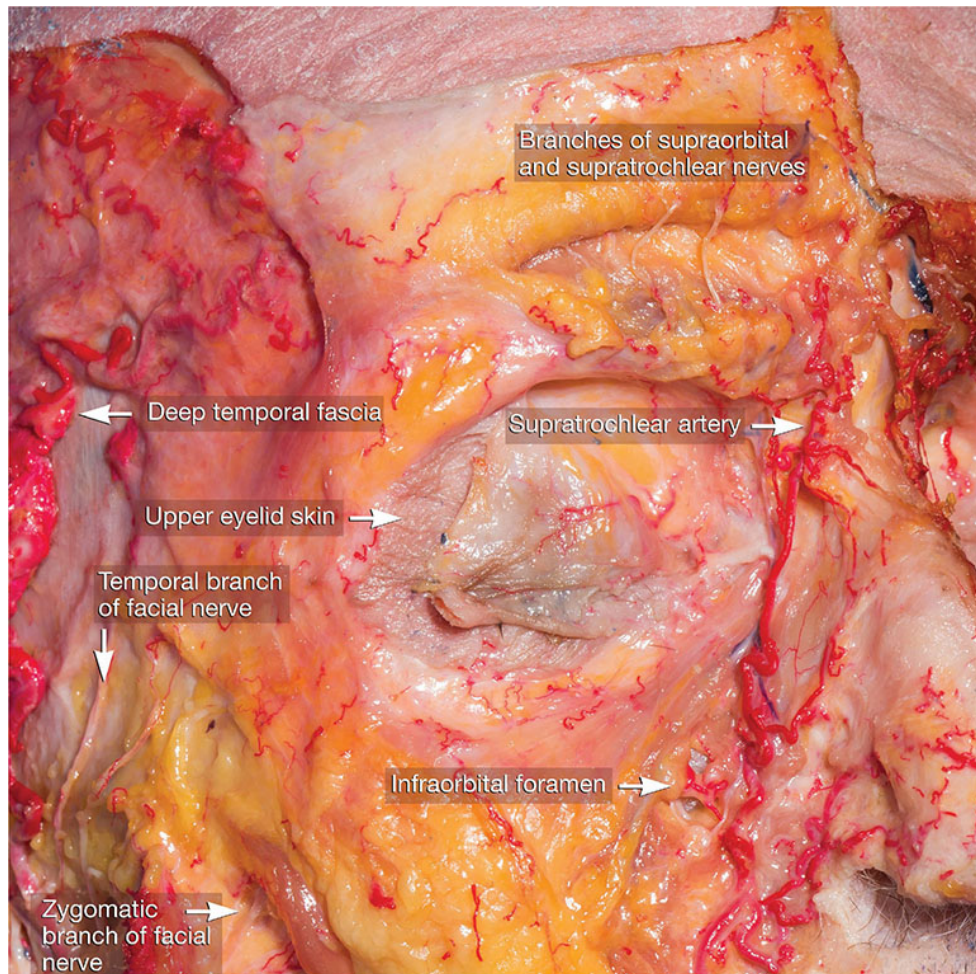


Figure 1-14. Dissection demonstrating relationship between superficial temporal artery and temporal branch of the facial nerve.

Superficial orbital region and eyelid

- Skin of the eyelids is very thin with only a thin fascial layer between it and fibers of the orbicularis oculi muscle. There is no fat beneath the dermis.
- Lacrimal canaliculi are deep to the medial canthal tendon.
- The angular artery and vein cross the medial canthal tendon and contribute to an important site of anastomosis just superior to the tendon between branches of external carotid (facial artery) and internal carotid (ophthalmic artery).

The orbital rim is formed laterally by the zygomatic process of the frontal bone and the frontal process of the zygomatic bone. The frontal bone forms the superior orbital margin as well as the roof of the orbit, with the superciliary arch of the frontal bone defining the superior orbital rim.

Along the mid-pupillary line, the superior orbital rim presents a notch, sometimes a foramen ($>25\%$), known as the supraorbital notch/foramen, through which the supraorbital vessels and nerves are transmitted (Fig. 1-9).

The medial orbital margin is formed by the maxillary process of the frontal bone along with the frontal process of the maxillary bone. The maxillary bone forms the floor of the orbit and the infraorbital rim. The lateral canthus lies in contact with the sclera, whereas the medial canthus is separated from the sclera by the caruncle and the lacrimal lake. The caruncle contains sweat and sebaceous glands, whereas the lacrimal lake provides a collection area for tear fluid before passing through the lacrimal canaliculi.

The skin around the eyelids is very thin, with only a thin fascial layer between it and the fibers of the orbicularis oculi muscle. Unlike the usual anatomic relationship of skin to subcutaneous tissue, there is no fat beneath the dermis. Understanding this arrangement provides insight into the depth of dissection as the subdermal space is approached. There are no significant superficial nerves or vessels in this subfascial space. Additionally, skin over the tarsal plates is tightly adherent, whereas the preseptal area allows for greater mobility. Another point of importance when understanding the layers of tissue around the eye is to remember that the region over the orbital septum, just proximal to the tarsal region, presents with several layers. Following the skin, subcutaneous tissue orbicularis oculi, and orbital septum, there is a layer of orbital fat followed by the aponeurosis of the levator palpebrae superioris, Muller's muscle, and then conjunctiva (Fig. 1-15).

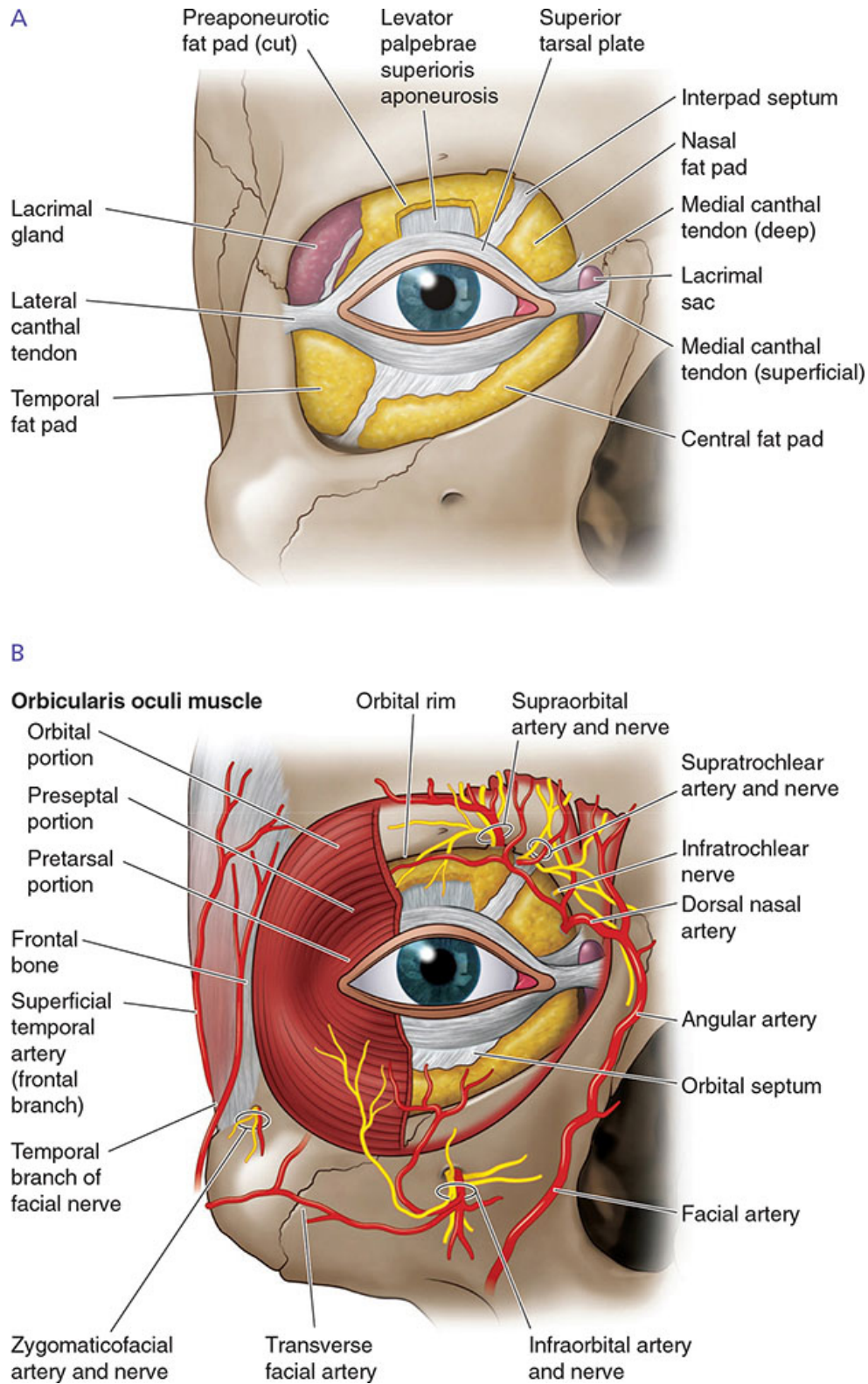


Figure 1-15. Diagram illustrating basic anatomy of the eye.

The orbicularis oculi and levator palpebrae superioris muscles are two predominant muscles of surgical concern. The orbicularis oculi is best described as two parts—the orbital portion and the palpebral portion. These portions of the muscle contract independently, the orbital portion under voluntary control and the palpebral fibers under both voluntary and involuntary control. The upper portion is innervated by the temporal branch of the facial nerve, whereas the lower fibers are innervated by the zygomatic branch of the facial nerve. The action is to tightly close the lids together. The orbital fibers attach to the orbital rim and blend in with the surrounding muscles of facial expression—the frontalis superiorly and the procerus medially. Corrugator supercilii lies beneath the medial aspect of the orbital fibers, and their origin from the medial orbital crest and insertion into the upper medial portion of the eyebrows bring the eyebrows medially.

The palpebral portion of the orbicularis oculi overlies the pretarsal and preseptal regions. Preseptal fibers cover the orbital septum of both upper and lower lids. It is important to note that the upper and lower preseptal fibers attach to the respective areas of the medial canthal tendon, and this arrangement has significant impact on the functioning of the lacrimal canaliculi. The continuation of these fibers laterally toward the lateral canthal tendon helps in bringing the lids together to produce winking and blinking actions. The pretarsal portion is attached firmly to the tarsal plate. Their connections maintain a similar anatomical arrangement as the medial and lateral preseptal muscles and are connected to the medial and lateral canthal tendons. The palpebral muscle unit is an important contributor to the mechanism of tear movement.

The medial canthal area is frequently a site for surgical excisions. Several important anatomical structures should be considered when working around this area. The lacrimal canaliculi are deep to the medial canthal tendon. However, they are secured at a deeper plane and relatively protected by an undisrupted tendon. The angular artery and vein traverse the area on their ascent within the nasolabial groove. They cross the medial canthal tendon and contribute to an important site of anastomosis just superior to the tendon between branches of the external carotid (facial artery) and internal carotid (ophthalmic artery) (Fig. 1-9).

The upper lid has two fat pads: the pre-aponeurotic and nasal units,²² and it may be difficult to distinguish between them and the lacrimal gland which lies in a lateral position on the upper lid. The lower lid contains a nasal,

central, and lateral fat pad. Their connection to the orbital septum laterally and via its fascia to the inferior oblique muscle medially makes the muscle susceptible to injury (Fig. 1-15). The levator palpebrae superioris and its aponeurosis are responsible for raising the eyelid, and are innervated by the oculomotor nerve. It is important to remember that the muscle arises in the apical region of the orbit and continues in its superior most location in an anterior direction. It is easily identifiable during dissection as it exists as a well-defined, flat, or sometimes more bulky muscle. As it approaches anteriorly, it divides into an aponeurosis, and posteriorly reflects into Muller's tarsal muscle. Fibers also attach to the orbicularis oculi and are connected to the overlying skin by fibrous strands. The lower lid is retracted by the extraocular inferior rectus muscle and also contains a tarsal muscle.

The tarsal plates are dense fibrous tissue plates that begin at the lacrimal puncta medially and extend to the lateral commissures. Numerous meibomian sebaceous glands are embedded vertically within the tarsal plates.^{4,22}

As previously mentioned, arterial supply to the eyelids is derived from extensive anastomosis between the internal and external carotid arteries. Branches from the ophthalmic, facial, and superficial temporal arteries perfuse both the upper and lower lids. Additionally, the maxillary artery via the infraorbital artery also contributes to the extensive vascularity, as its branches anastomose with the ascending branches of the transverse facial, facial, and angular arteries. The main venous drainage of the eyelids occurs via the superficial temporal, angular, and facial veins. Both arterial and venous systems present as vascular arcades along the upper and lower lids (Fig. 1-16).

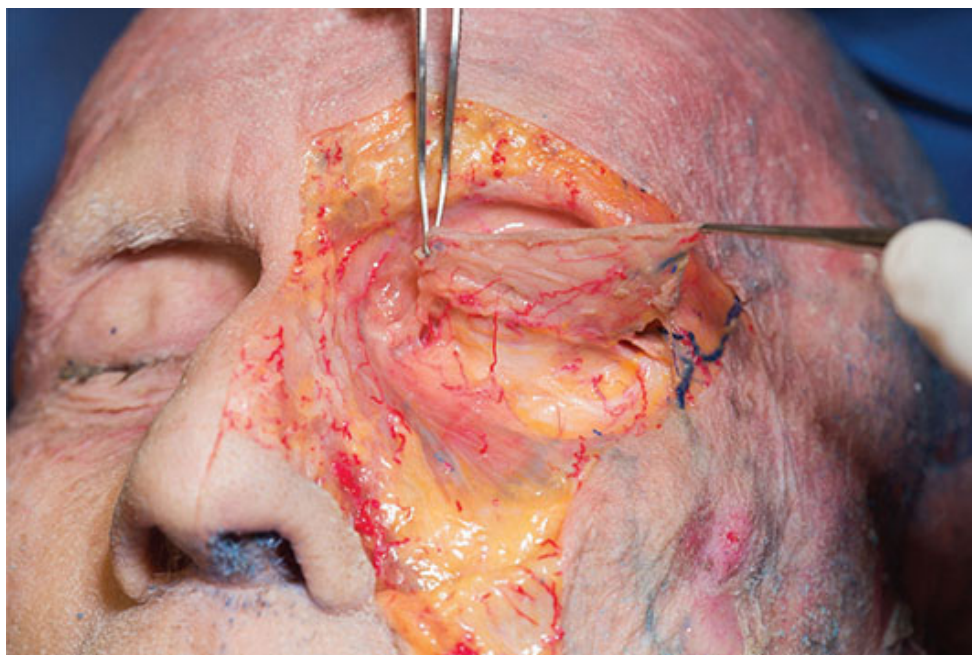


Figure 1-16. Dissection demonstrating arterial arcades around the eyelids.

Nose

- The nose is divided into root, dorsum, lateral walls, tip, alae, and columella.
- Most of the alae are composed of skin and fibrofatty tissue.
- Blood supply is mainly from angular artery externally and the sphenopalatine artery internally, with smaller contributions from the superior labial and ophthalmic arteries.
- Sensory innervation is derived from infraorbital branch of the maxillary nerve and infratrochlear and external nasal branches of the anterior ethmoidal nerve (ophthalmic nerve).

The challenge with conducting surgery on the nose is twofold. On the one hand, the nose presents with complex anatomy consisting of skin, cartilage, and nasal mucosa within a rather small anatomical boundary. Secondly, the mid-face location of the nose places a premium on cosmetic outcome, which reinforces the importance of thoroughly understanding the anatomy that will facilitate effective surgical repair and outcome. In its simple description, the nose may be divided into the root, dorsum (bridge), lateral side walls, and

the lobule (Fig. 1-17). The lobule is further divided into the nasal tip, the infra-tip, and the alae. When viewed from below, the infra-tip lobule presents a soft triangular area anteriorly, a columella that extends inferiorly and separates two nostrils bound by the nostril sills, and laterally the alar base and rim. Together, the bony pyramid, septum, alar cartilages, and the cartilaginous vault form the main structural support of the nose.

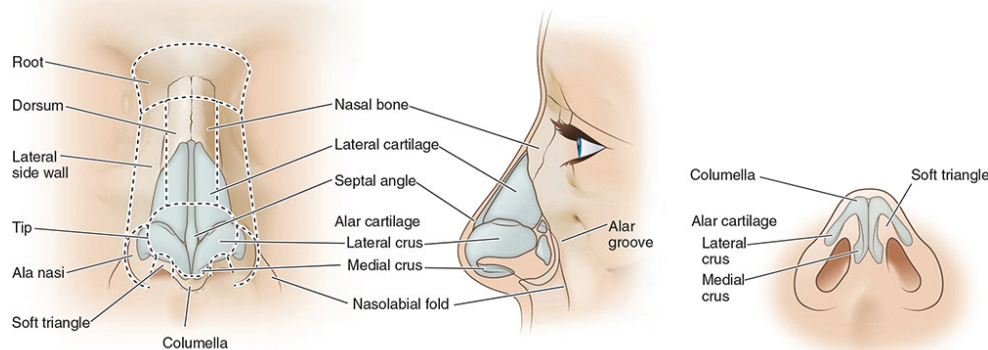


Figure 1-17. Diagram illustrating basic anatomy of the nose.

The nasal bones articulate along the midline and with the frontal processes of the maxillae laterally. Superiorly, the nasal bones articulate with the nasal processes of the frontal bone and inferiorly with the perpendicular plate of the ethmoid bone. Nasal bones are thickest superiorly but thin out inferiorly where they may be easily damaged. There is an overlap between these lower and upper borders of the lateral cartilages. Skin over the bony pyramid is loose, fairly mobile, and can be easily undermined.^{22,23}

The lateral cartilages are a continuation of the nasal bones, being overlapped superiorly by these bones and inferiorly by the upper border of the lateral crura of the alar cartilages. Ligamentous tissue connects both these overhangs.

The nasal septum consists of bone, cartilage, and soft tissue which include all of its articulating craniofacial bony structures. A septal or quadrangular cartilage anchors to the perpendicular plate of the ethmoid bone and maintains structural integrity of the bony septum. The membranous septum, a soft tissue composite, consists of two layers of vestibular skin separated by loose connective tissue. Depressor septi muscle traverses the membranous septum and attaches to the inferior border of the septal cartilage.^{4,22}

The lobule is the most mobile portion of the nose due to the lack of any fixed cartilaginous joints. The support of the lobule comes from the paired alar cartilages suspended by soft tissue ligaments. The soft tissue portion of the ala does not contain cartilage but rather is structurally maintained by a thickened dermis with no underlying subcutaneous fat, making detecting an ideal dissection plane challenging in this area.

The key muscles around the nose include procerus, levator labii superioris alaeque nasi, nasalis, and depressor septi muscles. Procerus extends from the frontalis muscle across the root of the nose and blends in with the transversely positioned nasalis muscle. It is important to remember that the plane deep to nasalis is continuous with the subgaleal plane, which maintains a bloodless field of dissection. The levator labii superioris alaeque nasi arises from the maxilla and sends fibers to the medial upper lip and the lateral ala. The most medial portion of these muscle fibers is referred to as the depressor septi, which pulls down on the septum and keeps the airways patent ([Fig. 1-18](#)).

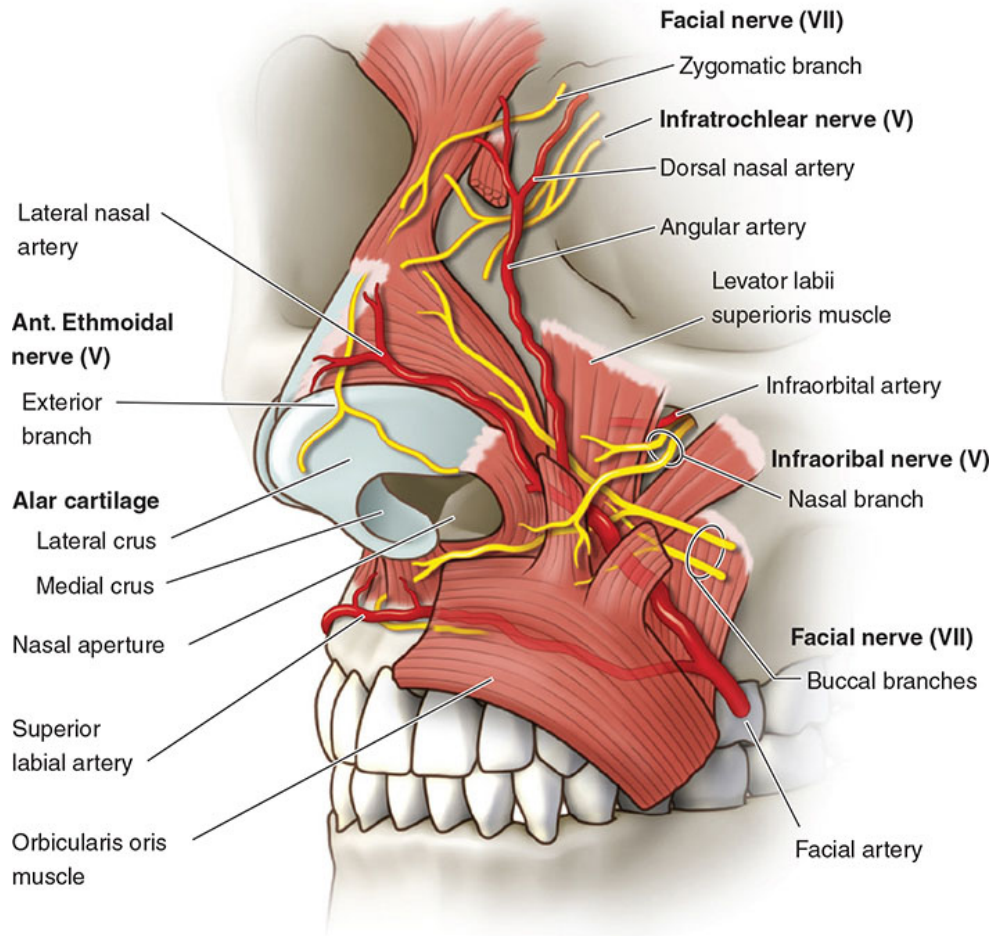


Figure 1-18. Diagram illustrating deeper anatomy around the nose.

The nose receives a rich blood supply which is a surgical advantage and allows for versatility in flap design and orientation. While blood supply is mainly from the angular artery externally and the sphenopalatine artery internally, with smaller contributions from the superior labial and ophthalmic arteries, the largest vascular contribution is derived from the external carotid system. The superior and inferior labial arteries are branches off the facial artery and they continue along the lateral aspects within the nasolabial grooves as the ascending angular artery en route to the medial canthal anastomotic site. The angular artery gives off many small branches to the sidewalls, ala, and dorsum, and form free and contralateral anastomoses terminating through a connection with the dorsal nasal artery (Fig. 1-19). This point of anastomosis is highly predictable, and its consistent presentation makes it a very viable pedicle for flap construction. The

glabella and mid-portion of the forehead is supplied by the supratrochlear artery, a branch of the ophthalmic artery that is also a reliable vascular pedicle in nasal reconstruction of the dorsum and tip of the nose (Fig. 1-20). Deep to the nasal bone, the external nasal artery emerges onto the dorsum of the nose (Fig. 1-21). It is usually accompanied by the external branch of the anterior ethmoidal nerve which supplies sensory innervation to the dorsum and tip of the nose. The infraorbital artery also contributes to vascular anastomosis around this area. Venous drainage follows the pattern of arterial supply and does not display any anatomy of significance.



Figure 1-19. Dissection demonstrating ascent of the facial and angular artery within the nasolabial region.

Sensory innervation to the nose is achieved through branches of the ophthalmic and maxillary divisions of the trigeminal nerve. Ophthalmic division supplies the area along the midline of the nose, whereas the maxillary division via the infraorbital nerve ([Fig. 1-20](#)) innervates the alae, lower lateral walls, and columella. The root and upper nasal bridge along with the upper lateral walls is supplied by the infratrochlear nerve that approaches the nose in a medial direction from above the medial canthal tendon.



Figure 1-20. Dissection of the anterior left cheek highlighting the infraorbital nerve.

Ear

- The external ear is divided into the auricle (pinna), the external auditory meatus and canal, and the external surface of the deeper set tympanic membrane.
- Blood supply to the ear is derived from superior and inferior auricular branches of the superficial temporal artery and the deep auricular branch of the maxillary artery.
- The external ear receives a rich sensory innervation from overlapping cranial and cervical nerves.
- The auriculotemporal nerve travels posterior to the superficial temporal vessels and supplies the anterior portion of the auricle and anterior helix.
- The auriculotemporal nerve lies posterior to the superficial temporal artery and vein, and exits the superior parotid fascia as it traverses the parotid gland.
- The mastoid area is supplied by C2, C3 ventral rami derived via the lesser occipital nerve. Concha is supplied by variable overlapping innervation from cranial nerves VII, IX, and X, which also supply the posterior aspect of the external meatus and tympanic membrane and posterior auricular sulcus.

For the dermatologic surgeon, understanding the architecture of the ear is essential to repairing both large and smaller defects. When undermining, performing a primary closure, or during mobilization, knowledge of the variation in skin thickness, elasticity, relationship to the underlying cartilage, and pattern of perfusion helps in producing the most effective repair.

The external ear is divided into the auricle (pinna), the external auditory meatus and canal, and the external surface of the deeper set tympanic membrane.²² The auricle consists of a complex cartilaginous framework that is thrown into folds and grooves. The cartilage is covered by tightly bound skin with very little subcutaneous tissue, often with no subdermal fat at all. While the skin is tight anteriorly, posteriorly it offers a little more flexibility. The most inferior portion of the auricle, the lobule, has no cartilaginous base and consists of subcutaneous fat and skin. There are two distinct curves that extend superior to the lobule: (1) the outer helix—an anteriorly curved fold that continues posterosuperiorly from the lobule toward the upper limit of the tragus where it blends in with the crus of the helix; and (2) the antihelix,

separated from the helix by a groove known as the scaphoid fossa. The tragus, an anterior extension of the auricular cartilage, is separated from the antitragus by the intertragal space. A deep concave groove referred to as the concha leads to the external auditory meatus. The concha is further subdivided into a more superior impression, the cymba, and an inferior, larger impression, the cavum (Fig. 1-22).^{4,9,22}

While variations exist, in its standard anatomical position the ear is situated laterally, lies somewhat between the eyebrows and the base of the nose with the helix protruding beyond the antihelix. Ligamentous fibers connect the auricle to the skull and contain rudimentary intrinsic muscles. Extrinsic muscles are of little clinical significance, but it is helpful to note that these muscles of facial expression—the anterior, posterior, and superior auricular muscles—are contained within the SMAS and innervated by branches of the facial nerve.

The length of the external auditory meatus and canal measures 2.5 to 3.5 cm. The canal itself has both bony and cartilaginous parts.²² Laterally, the cartilaginous component is continuous with the auricular cartilage, while medially, it is attached to the bony meatus. The cartilaginous portion is mostly present in the inferior aspect of the canal. Superiorly, the canal is bound by the squamous temporal bone. The true bony portion of the canal tunnels between the squamous and tympanic parts of the temporal bone. Around the lateral portion of the external meatus the skin is thicker, with sebaceous, cerumeniferous glands and hair. The bony portion contains very thin layer of epithelium and is devoid of hair and glands. Of particular clinical interest are the fissures within the cartilaginous portion of the canal. These randomly arranged fissures, known as fissures of Santorini, offer potential avenues for developing skin cancers to spread into surrounding tissue.

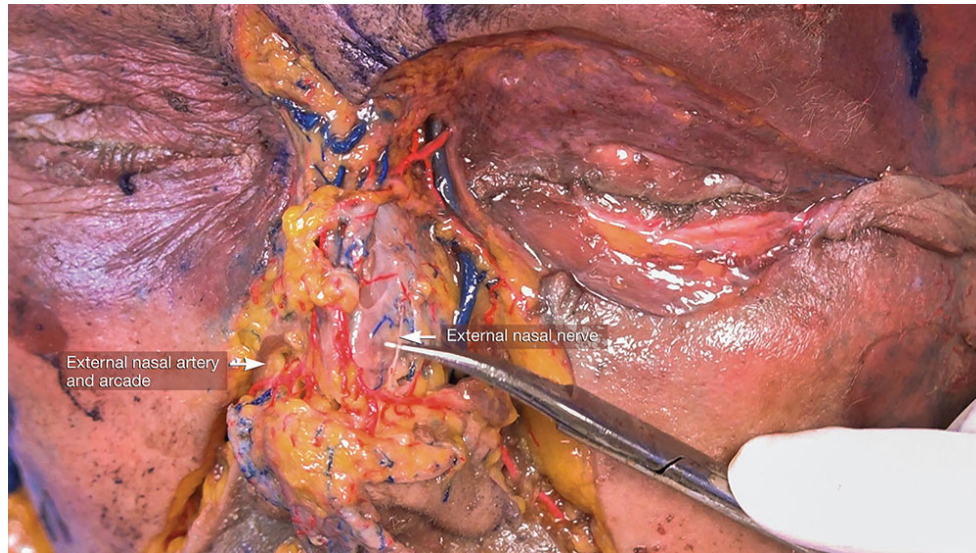


Figure 1-21. Superficial dissection of anterior nose demonstrating the external nasal nerve and vessels.

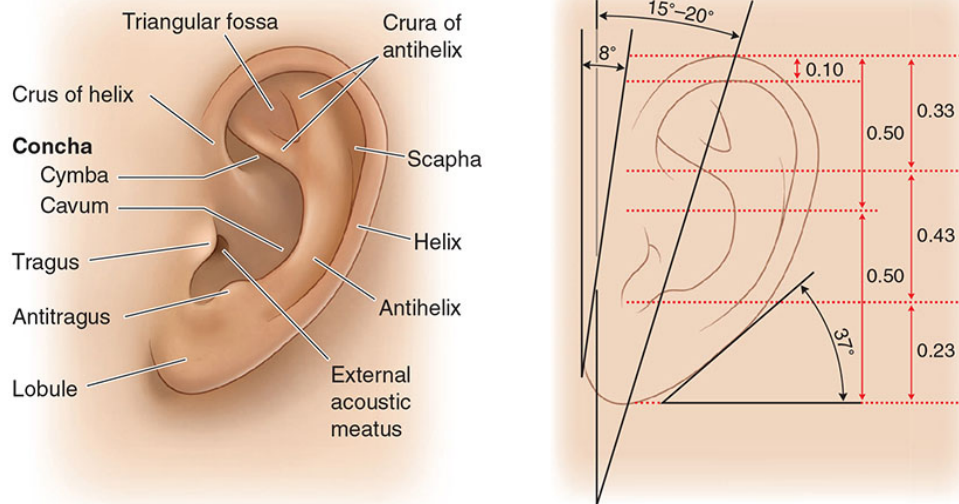


Figure 1-22. Diagram illustrating basic anatomy of the external ear.

The rich blood supply to the ear is derived from superior and inferior auricular branches of the superficial temporal artery and the deep auricular branch of the maxillary artery. Additionally, the posterior auricular artery, a branch of the external carotid artery, supplies the posterior aspect of the ear. Arterial branches are arranged as a single layer of vessels within the skin as a consequence of the sparsity of subcutaneous fat. The venous pattern

corresponds with the arterial supply, and drainage is via the superficial temporal and retromandibular veins.

The external ear receives rich sensory innervation from overlapping cranial and cervical nerves. The mandibular division of the trigeminal nerve gives off the auriculotemporal nerve, which travels posterior to the superficial temporal vessels and supplies the anterior portion of the auricle and anterior helix. Additionally, the auriculotemporal nerve supplies the anterior and superior walls of the auditory canal as well as a portion of the external surface of the tympanic membrane (Fig. 1-13). Injury to the auriculotemporal nerve may be limited by recalling that it lies posterior to the superficial temporal artery and vein and that inferiorly it exits the superior parotid fascia as it traverses the parotid gland. The great auricular nerve (C2, C3 ventral rami) supplies most of the medial surface of the auricle as well as the posterior portion of the lateral surface of the auricle. This will include most of the helix and antihelix. The mastoid area is also supplied by C2, C3 ventral rami but its innervation is derived via the lesser occipital nerve. The concha is variably innervated by cranial nerve VII, and the meatus is innervated by cranial nerves IX and X.^{4,9,22} These cranial nerves also supply the posterior aspect of the external meatus and tympanic membrane and posterior auricular sulcus.

Lips and Chin

- Orbicularis oris muscle has no bony attachment and is innervated by the buccal branch of the facial nerve through its deep surfaces.
- Blood supply is derived from superior and inferior labial arteries arising from the facial artery.
- Innervation of the upper lip is achieved via the infraorbital nerve (V2) and of the lower lip via the mental nerve (V3).
- Redundancy of skin as well as mucosa around the commissural junction enables mobility and flexibility when the mouth is opened.
- Sensory innervation to the chin is supplied by the mental nerve branches (V3).
- Lip depressor muscles and mentalis are innervated by the marginal mandibular branch of the facial nerve.

Surgery of the lips lends itself to both cosmetic and functional importance. Disruption of the architectural contour of the lips has far-reaching consequences for the patient, making preservation and restructuring of the anatomy of utmost importance. While not often considered, the lip constitutes more than just the vermilion.²² It extends superiorly to the nose and inferiorly to the chin, corresponding with the circularly arranged fibers of the orbicularis oris muscle. The boundary line of the upper lip lies at the junction of the columella, nasal sill, and alar crease below the base. Laterally, the upper lip extends to the nasolabial fold, a point at which the lip elevators insert into the orbicularis oris fibers. The upper lip is divided by a vertically placed philtrum bound by philtral columns on either side and inferiorly by a downward arch referred to as Cupid's bow. The vermilion is composed of a modified mucosal membrane with a rich underlying vascular supply. There are no underlying sweat, salivary, or sebaceous glands.^{4,22} A redundancy of skin as well as mucosa around the commissural junction enables mobility and flexibility when the mouth is opened. A group of muscles of facial expression for elevation, depression, and retraction insert deep to the commissural skin.

The underlying anatomy of the lip is not complex, and contains the orbicularis oris fibers covered by mucous membrane (toward the oral cavity) and skin. The muscle fibers have a very close relationship with the dermis via muscular slips, limiting the ease with which dissection and reflection of the skin are possible. Bulging of the muscle fibers creates a corresponding surface marking known as the "white roll" or "white line" along the vermilion–cutaneous junction.^{4,9,22} Orbicularis oris muscle has no bony attachments, and is circumferentially arranged to facilitate sphincteric action.

Motor innervation of the orbicularis oris is derived from the buccal branch of cranial nerve VII. Most of the angle elevators as well as the lip itself are supplied by the buccal branch. As the buccal branches exit the parotid fascia, they flank the parotid duct as they travel medially toward the orbicularis fibers to then pass deep to the muscle, innervating it from the deep surface (Fig. 1-23). The marginal mandibular branch of cranial nerve VII contributes to the depressors, again passing through the deep surface of the muscles. Sensory nerves are abundant and derived from the infraorbital branch of the maxillary nerve (CN V₂) (Fig. 1-24) reaching the upper lip, and from the mental nerve (terminal branch of the inferior alveolar nerve, a

branch of mandibular nerve CN V₃) reaching the lower lip. Numerous small branches are encountered upon reflection of the skin. The main nerve trunks, however, may be accessed at the infraorbital foramen and the mental foramen. The infraorbital and mental foramina are generally located in a fixed position relative to the alae and oral commissure, respectively.

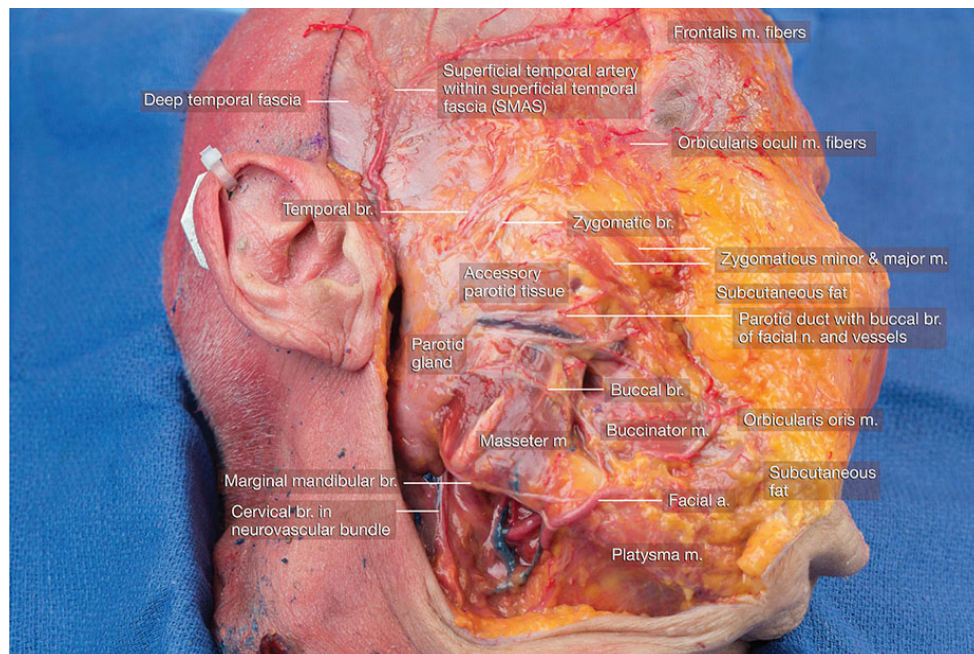


Figure 1-23. Dissection of the lateral face with skin and subcutaneous layers reflected medially.



Figure 1-24. Anterolateral view of lower face with skin and subcutaneous tissue over upper lip reflected inferiorly.

Blood supply to the lips is achieved through an anastomotic arterial arcade formed by the superior and inferior labial arteries (Figs. 1-24 and 1-25). These branches arise from the facial artery around the angle of the mouth. However, oftentimes the inferior labial artery may originate at a lower point, as the facial artery crosses over the angle of the mandible. With this branching pattern, the inferior labial artery may lie lower than its normal position and ascend toward the midline of the chin. Both the superior and inferior labial arteries are often highly tortuous, especially in older individuals, and run deep to the fibers of orbicularis oris. Skin over the lips is supplied by vertically ascending and descending branches off the arcades.



Figure 1-25. Lateral view of dissection of regional anatomy around the mid cheek and mandibular region.

The chin is a relatively fixed anatomical structure that is composed mostly of muscles of facial expression acting on the lower lip. The chin extends from the mentolabial crease to the most inferior point along the midline of the mandible. In older individuals, RSTLs are visible and can be distinguished between (1) the radially extending lines around the lower lip area with diagonal extensions toward the angles of the mouth and (2) the variable lines

around the mental region that are determined by the shape of the chin.²² As the muscles of facial expression insert directly into the skin, very little subcutaneous tissue is found in this area. Creating a dissection plane is somewhat difficult as the taut insertion of the muscles limits undermining in this region.

Muscles of the chin include overlapping fibers of the orbicularis oris muscle that mingles with the fibers of the platysma and other surrounding regional muscles. Laterally, the depressor anguli oris attaches to the medial aspects of the mandible and the oral commissure to pull the angle of the mouth downward. On the front of the mandible, the depressor labii inferioris is partially overlapped by the depressor anguli oris. Two slips of the mentalis muscle arise from the mandibular midline and insert onto the skin of the chin, maintaining a variable gap between them (Fig. 1-3). All these muscles are supplied by the marginal mandibular branch of the facial nerve. The marginal mandibular nerve is easily visualized as it passes along the bony margin to enter the chin deep to the angle of the mouth. Since the marginal mandibular nerve is often seen as a single exposed trunk before branching to supply these muscles, injury to the trunk will result in unopposed action of the antagonists of these muscles (Fig. 1-26).

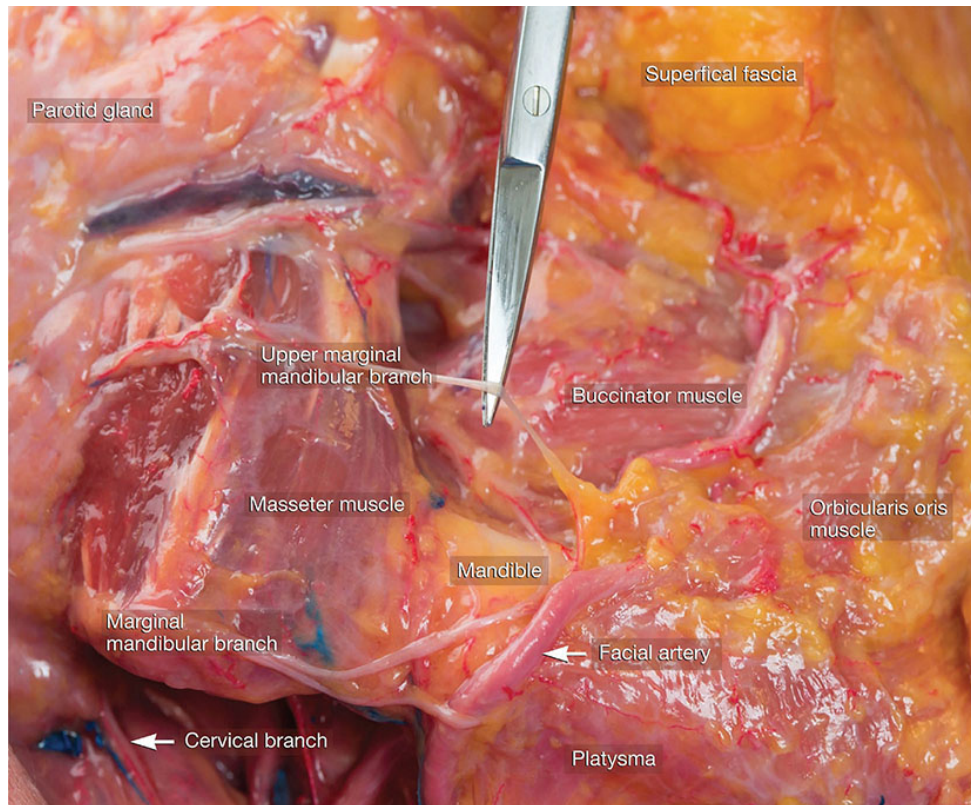


Figure 1-26. Dissection highlighting the marginal mandibular branch of the facial nerve and its relationship to the facial artery.

The mental nerve exits the mental foramen as a terminal branch of the inferior alveolar nerve. It is a purely sensory nerve and displays a tuft-like branching pattern. With aging, mandibular bone resorption may change the relative location of the mental foramen, bringing it a little higher toward the superior margin due to the decreasing height of the alveolar processes.

Cheek

- The anterior region includes the buccinator muscle, buccal fat pad, buccal branches of the facial nerve, and the downward traversing parotid duct.
- The parotid region is dominated by the parotid gland and underlying deep masseter muscle.
- The parotid duct and facial artery are easily identifiable landmarks in this region.

- The marginal mandibular nerve is a key structure in the mandibular region as it consistently crosses the facial artery deep to the fibers of platysma.

Anatomically, the cheek extends from the anterior border of the ear, limited medially by the nose, lips, and chin, and from the mandible up to the zygomatic arch and orbital rim. However, to best appreciate the cosmetic unit of the cheek, it is best described in three regions: the anterior, mandibular, and masseter–parotid regions.^{4,9,22}

The *anterior region* contains many of the muscles of facial expression. The risorius is very superficial and of variable size, sometimes even absent. The zygomaticus major and minor as well as the levator labii superioris and the levator labii superioris alaeque nasi originate from the zygomatic bone and orbital rim, and are overlapped by the fibers of the orbicularis oculi muscle. When reflecting the skin over this region, zygomaticus minor is seen more superficially than the rest of the muscles, with only a few millimeters of subcutaneous tissue overlying it (Figs. 1-6 and 1-23). Since the facial nerve branches maintain their course and innervation deep to the muscles, injury to these branches is less likely provided that the plane of dissection remains superficial to the muscle plane.

Along the medial aspect of the anterior cheek, the facial artery can be seen anterior to the facial vein after crossing the mandible to ascend toward the angle of the mouth where it gives off the labial branches and subsequently traverses the nasolabial groove as the angular artery. Within the nasolabial groove, the angular artery can be accessed with little difficulty by dissecting within the subcutaneous tissue and overlying muscle slips of the zygomaticus major and minor muscles (Fig. 1-19). The angular artery then terminates at the medial canthus just above the medial canthal tendon by anastomosing with the ophthalmic branch of the internal carotid artery (Fig. 1-19). The deepest structures in this region of the cheek are the buccinator and levator anguli oris muscles. Unlike the other muscles of facial expression, the buccinator is a relatively fleshy muscle. It lies within a drop-down plane covered by a significant amount of fatty tissue, often referred to as the buccal fat pad (Fig. 1-25). The buccinator is pierced by the parotid duct as well as blood vessels and buccal branches of the maxillary nerve en route to supply sensory innervation to the buccal mucosa.^{4,9,22} The buccal fat pad itself lies technically in the medial cheek. This fatty mass is well defined and contained

by a thin layer of fascia, and on its surface the facial nerve branches can be visualized crossing over the fat pad still deep to the SMAS (Fig. 1-6). Superiorly, the infraorbital nerve branches out as a leash of nerves to supply sensory innervation to the medial cheek. The supraorbital foramen is easily palpated on most individuals.

The *masseter–parotid region* offers a very important anatomical landmark—the deeply set masseter muscle. A muscle of mastication supplied by the trigeminal nerve, the masseter can be easily visualized and palpated when the jaw is clenched. Its strong attachments extend between the zygomatic arch and the ramus of the mandible, and its anterior musculotendinous border provides an important landmark for key facial structures. The posterior half of the masseter is covered by the parotid gland. Contained within its own fascia, the parotid gland, wedged along the preauricular mandibular region, is separated from the masseteric fascia which is a continuation of the superficial layer of deep cervical fascia. The lower anterior portion of the masseter may be overlapped by the fibers of the platysma in most individuals.

When visualized on unembalmed cadaveric specimens, the parotid gland displays a yellowish color, very similar to the living patient. It may sometimes be confused with subcutaneous fat as it is relatively close to the skin itself (Fig. 1-23). Unlike the subcutaneous tissue, however, the parotid gland is contained within a shiny, tight fascial sheath, the parotid fascia, which may help in differentiating it from fat. On the anterior border of the gland, the parotid duct can be located as it travels horizontally and then downward into the buccal fat. It consistently crosses over the masseter muscle before turning sharply toward the buccinator to pierce it and enter the oral cavity opposite the upper second molar. From its surface anatomy, the parotid duct may be located in the region of intersection between the tragolabial line,²² and the anterior edge of the masseter muscle and, additionally, along the zygomatic arch about 2 cm below it. The parotid duct is a prominent structure and provides a reliable anatomical landmark. As the parotid duct lies deep to the SMAS, it is crossed by fibers of the zygomatic branch of the facial nerve and also flanked by the upper and lower buccal branches of the facial nerve (Figs. 1-5, 1-6, and 1-23).

The transverse facial artery, arising from the external carotid artery, passes parallel to the parotid duct between it and the zygomatic arch. It also crosses over the anterior margin of the masseter muscle. The superficial

temporal artery exits the parotid fascia below the zygomatic arch just anterior to the tragus (Fig. 1-27).^{4,9,22} It passes posterior and deep to the parotid gland as one of the terminal branches of the external carotid artery. The facial artery and vein (posterior to the artery) also travel beneath the SMAS as they cross over the mandible. The facial artery and vein can be located just anterior to the masseter muscle. The facial artery, which travels in a tortuous ascending course, is often more prominently tortuous in older individuals. The mandibular branch of the facial nerve crosses over the facial artery about 5 to 10 mm above the point at which the facial artery crosses the mandible.

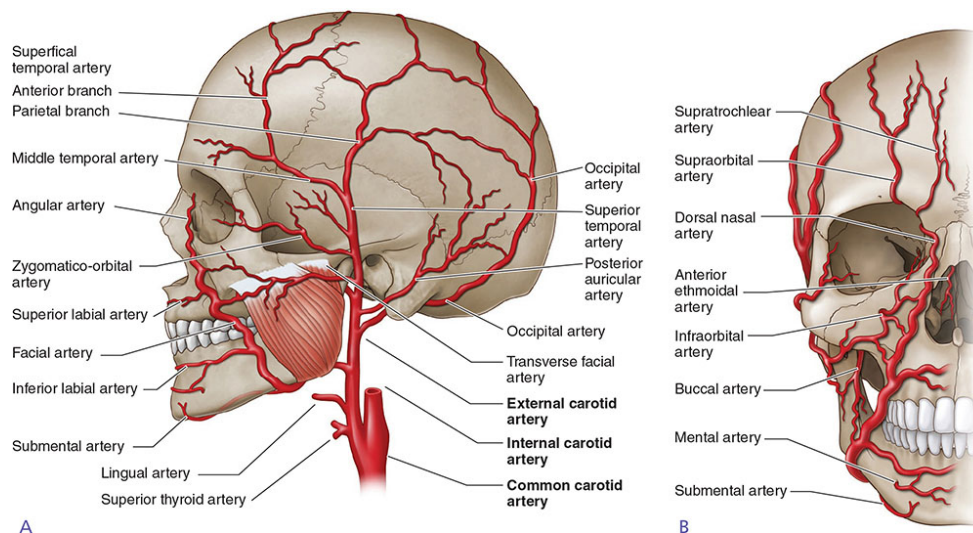


Figure 1-27. Diagram illustrating the arterial pattern and supply to the face.

The mandibular region extends from the anterior margin of the masseter muscle to the chin. Three predominant muscles are encountered after reflecting the skin in the region. The platysma lies within the superficial fascia and inserts into the skin of the lower lip, blending in with the fibers of the orbicularis oris muscle. The depressor anguli oris, which originates on the mandible and inserts onto the angle of the mouth, also sends fibers that blend in with those of the platysma and orbicularis oris.

Both the facial artery and the marginal branch of the facial nerve lie deep to the fibers of the platysma. In most individuals, the marginal branch of the facial nerve maintains a course above the mandibular rim, crossing the facial artery to supply the depressors of the lips and the mouth. While there are

usually two branches, the mandibular branch of the facial nerve can exist as a single nerve or have as many as four branches (Fig. 1-26).

SURGICAL CONSIDERATIONS

Muscles of the face

The muscles of facial expression and the superficial group of muscles of mastication form the basis for the muscular framework of the face (Fig. 1-3). Muscles of facial expression lie at varying depths just deep to the subcutaneous tissue. They attach from the facial skeleton to the overlying dermis in a 3D configuration from deep to superficial.^{2,3,6,14,27} Seen from this four-layered overlaying construct, the deepest muscles include buccinator, mentalis, and levator anguli oris. At the next level, the orbicularis oris and levator labii superioris can be visualized, followed by the more superficial depressor labii inferioris, risorius, platysma, zygomaticus major, and levator labii superioris alaeque nasi. Fibers of the depressor anguli oris, zygomaticus minor, and orbicularis oculi can be identified most superficially. All the muscles (except for the deepest layer) are innervated by the branches of the facial nerve passing through their deep surfaces.^{4,9}

Branches of the facial nerve

Facial nerve branches, while generally protected by the SMAS, are surgically vulnerable as they reach areas of transition along their course toward their final destination.

Injury to the facial nerve and its branches during surgical exposure has been a topic of detailed discussion.^{2,5,6,15,28–32} A few key points can help guide dissection around facial nerve branches: (1) Facial nerve exits its intracranial course through the stylomastoid foramen and immediately gives off the posterior auricular nerve which passes behind the ear toward auricularis posterior and the occipital belly of occipitofrontalis muscles. (2) At the posteromedial surface of the parotid gland, just before this point or within the gland, the facial nerve branches into a superior temporofacial and inferior cervicofacial division. (3) Facial nerve divides and reconnects through an extensive branching pattern before it exits the parotid fascia along

the medial margin to give rise to five main trunks: temporal, zygomatic, buccal, mandibular, and cervical.^{4,9,29} (4) Main branches lie within the parenchyma of the parotid gland and are not at risk for injury during superficial surgical procedures unless the parotid gland or parts of it have been resected (Fig. 1-4). (5) Vulnerability to injury of the facial nerve branches increases as they travel toward their areas of innervation. (6) Facial nerve branches are most susceptible to injury in their transition from Layer 5 (deep fascial plane) to Layer 4 (soft tissue spaces).^{2,15,29} (7) Along their course, branches of the facial nerve lie deep to the SMAS and can be safely encountered as long as the plane of dissection is maintained above the SMAS (Fig. 1-6).

Anatomic points of consideration to limit vulnerability of facial nerve branches to injury

1. Temporal branches emerge from the upper margin of the parotid fascia and cross the zygomatic arch. Usually three to four branches supply frontalis and parts of orbicularis oculi (Figs. 1-4, 1-6, and 1-14).
2. Zygomatic branches cross the zygomatic arch and bone and are in direct contact with periosteum. As they cross the bony eminence, they lie directly under the skin with no subcutaneous protection (Figs. 1-4, 1-6, and 1-23).
3. Buccal branches flank the parotid duct along its upper and lower margins. Keeping the parotid duct in view helps maintain a safe zone limiting injury to the buccal branches as they travel toward the buccinator, nasalis muscle fibers, and the upper portions of the orbicularis oris muscle (Figs. 1-5 and 1-23).
4. The marginal mandibular branch travels frequently as a single branch, and often as two branches running above, along, or about 1 cm below the inferior border of the mandible. It consistently crosses over the facial artery, making it vulnerable to injury once the facial artery is approached. The platysma offers a layer of protection over the marginal mandibular branches and the mandible-traversing portion of the facial artery (Fig. 1-26).
5. The cervical branch is located deep to the platysma as it descends from the lower border of the parotid gland maintaining its position on the deep

surface of the muscle. It is only vulnerable to injury if the fibers of platysma are reflected (Fig. 1-23).

Anatomic points of consideration to avoid injury and maximize vascular sources for reconstruction

The superficial arterial supply to the face includes a rich anastomotic network of branches originating from the external and internal carotid arteries. Through extensive anastomoses, these major vascular trunks provide reliable pedicles and contribute to the microvascular infrastructure of the superficial face. The external carotid artery includes a vast network of arborizing, anastomotic, and tortuous arteries varying in size and depth within the fascial planes. The internal carotid artery via its ophthalmic branch supplies a central triangular area including the eyes, superior nose, and central portion of the forehead.^{4,9} The key area of anastomosis between external and internal carotid arteries is located above the medial canthal tendon where the angular artery communicates with the dorsal nasal branch of the ophthalmic artery (Fig. 1-19).

The superficial temporal artery ascends behind the temporomandibular joint, anterior to the tragus and auriculotemporal nerve. It crosses the zygomatic arch and branches over a wide surface deep to the skin and within the layers of the superficial temporal fascia. The supraorbital and supratrochlear arteries run along the same territory as a neurovascular bundle with the supraorbital and supratrochlear nerves. The larger supraorbital artery usually anastomoses with the superficial temporal artery (Fig. 1-12).

The anastomosis of the angular branch of the facial artery with the dorsal nasal artery above the medial canthal ligament is an area of surgical importance (Figs. 1-10 and 1-19). While the course of the facial artery within the nasolabial fold is well known, its infrequent course outside the fold has been documented. The artery has been recorded passing through the fold in up to 90% of individuals, and at least 5 mm outside the territory or crossing it in up to 45% of individuals.^{10,33} In the nasolabial region, the facial artery along with its superior and inferior labial arteries may not always maintain a submuscular position. Lee et al.³³ provide anatomical evidence for the vessels travelling superficial to the surrounding muscles of

facial expression and sometimes looping deep and superficial to the muscle fibers.

Anatomy of the neck

Understanding the superficial anatomy of the neck begins with the ability to visualize key structures bound by palpable landmarks. The topographic anatomy of the neck is marked by consistent musculoskeletal structures that present triangular spaces seen from the anterior and lateral aspects (Fig. 1-28). Surgical approaches to the neck can be enhanced by keeping the following anatomical points in perspective:

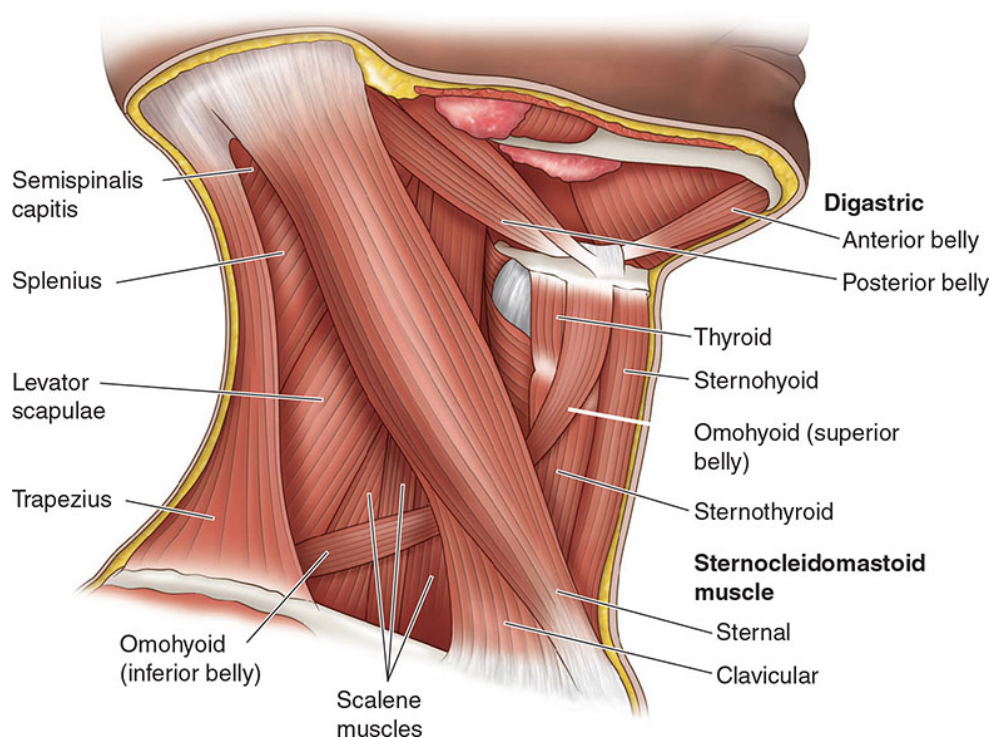


Figure 1-28. Diagram illustrating the anatomical boundaries and structures within the posterior triangle of the neck.

1. The most prominent landmark in the neck, the sternocleidomastoid muscle (SCM), provides the primary boundary for differentiating the anterior and posterior triangles.
2. The most superficial muscle of the neck, the platysma, is invested by superficial cervical fascia (continuous with the SMAS), creating a thin

muscular veil over the superficially traversing cutaneous nerves.

3. Superficial cervical nerves, the great auricular, lesser occipital and transverse cervical nerves, are encountered at the posterior border of the SCM when platysma muscle is reflected.
4. Erb's point, located 6 cm below the midpoint of a line connecting the angle of the mandible with the mastoid process, provides a landmark for the exit point of the superficial cervical nerves and the accessory nerve (cranial nerve XI).³⁴
5. The external jugular vein travels along a vertical course on the superficial surface of SCM anterior to the great auricular nerve to the base of the neck where it pierces the deep cervical fascia.

Triangles of the neck

The triangles of the neck are formed by visible and palpable landmarks of its musculoskeletal framework. The anterior triangle is bound posteriorly by the anterior margin of the SCM, superiorly by the inferior margin of the mandible, and anteriorly by the sternohyoid and sternothyroid muscles. The posterior triangle is bound anteriorly by the posterior border of the sternocleidomastoid and posteriorly by the anterior border of the trapezius muscle and lateral portion of the clavicle (Fig. 1-28).

The anterior triangle may be further subdivided by the posterior and anterior bellies of the digastric muscle and hyoid bone into the submental, submandibular, carotid, and muscular triangles (Fig. 1-29).

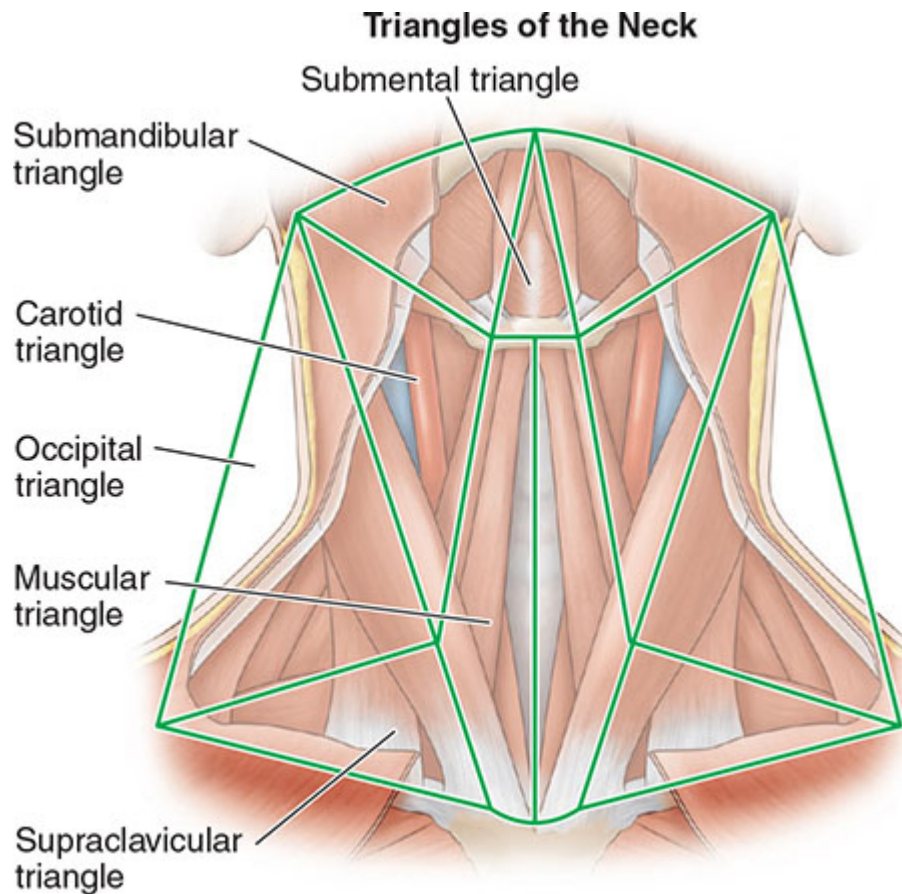


Figure 1-29. Diagram illustrating the sub-divisions of the triangles of the neck.

- **Submental triangle:** The flat mylohyoid muscle forms the floor, with the nerve to mylohyoid running along this surface; it contains few structures of significance other than subcutaneous fat, fascia, and lymph nodes.
- **Submandibular triangle:** The submandibular gland is the most prominent structure. It contains lymph nodes and the proximal portion of the facial artery as it courses between the parts of the submandibular gland; the low-hanging marginal mandibular branch of the facial nerve passing below the mandibular margin must be considered within this space.

- **Carotid triangle:** The carotid sheath containing the common carotid artery, internal jugular vein, and vagus nerve fills the space. The ansa cervicalis (branch of cervical plexus) motor contribution to strap muscles loops over the anterior surface of the carotid sheath; internal and external carotid arteries originate within this triangle; the hypoglossal nerve may be seen as it travels along the uppermost portion of the triangle from posterior to anterior.
- **Muscular triangle:** Contains the strap muscles (infrahyoid), including sternohyoid, sternothyroid, omohyoid and thyrohyoid muscles, and traversing muscular branches of the cervical nerves.

The posterior triangle ([Fig. 1-28](#)) can be further divided anatomically by the inferior belly of the omohyoid into the occipital and supraclavicular triangles. However, these divisions are rarely differentiated clinically. The deepest aspect of the posterior triangle, the floor, is formed by the parallel arrangement of deeper, smaller, neck muscles. Superiorly, the triangle contains the splenius capitus. Inferiorly, the levator scapulae (an important muscular landmark for isolation of the accessory nerve) lie above the posterior and middle scalene muscles. It is surgically useful to note that these muscles are covered by the prevertebral fascia (deep cervical fascia) on the top of which lies the superficial layer of deep cervical fascia.

In the next layer, two important nervous structures lie over and between the muscles of the floor of the posterior triangle. The proximal portion of the trunks of the brachial plexus lie anterior to the middle scalene muscle and are covered by the overlying prevertebral fascia. Injury to the trunks of the brachial plexus is unlikely as long as the prevertebral fascia remains uninterrupted.

Perhaps, one of the most emphasized structures of surgical interest in the posterior triangle is the accessory nerve (CN XI) ([Fig. 1-30](#)). As it descends over the levator scapulae muscle to pass beneath the trapezius muscle, the course of the accessory nerve can be traced along the midline of the posterior triangle. As the accessory nerve contains primary motor fibers to the trapezius muscle, injury during deeper surgical excisions will result in impaired function of the trapezius muscle (symptoms include winged scapula, inability to shrug shoulders, pain, initiation of arm abduction). The accessory nerve also provides motor innervation to the SCM muscle, but its branches to the SCM are less likely to be injured as they innervate the muscle on its deep

surface. In the posterior triangle, the accessory nerve is most vulnerable to injury in the 3- to 4-cm area between SCM and trapezius muscles. The accessory nerve can be distinguished from the surrounding cutaneous cervical nerves at Erb's point,³⁴ as it passes posteriorly along a diagonal course to become almost vertical within the posterior triangle. The great auricular nerve traverses the SCM, while the lesser occipital nerve remains close to the muscle along its ascent. The transverse cervical nerve passes horizontally across SCM in an anterior direction. During dissection, cervical nerves carrying proprioceptive fibers can be seen in a slightly more superficial plane travelling along the course of the accessory nerve. While the accessory nerve is a superficial structure and very vulnerable to surgical injury, it is still offered a layer of fascial cover as it lies between the prevertebral and superficial layers of deep cervical fascia. A consistent carpet of fatty tissue lies beneath the accessory nerve. The thickness of subcutaneous tissue of the superficial fascia over the nerve can vary between individuals. Additionally, proprioceptive fibers from the cervical plexus can be seen communicating with the accessory nerve and may sometimes be confusing when identifying the accessory nerve itself (Fig. 1-30).

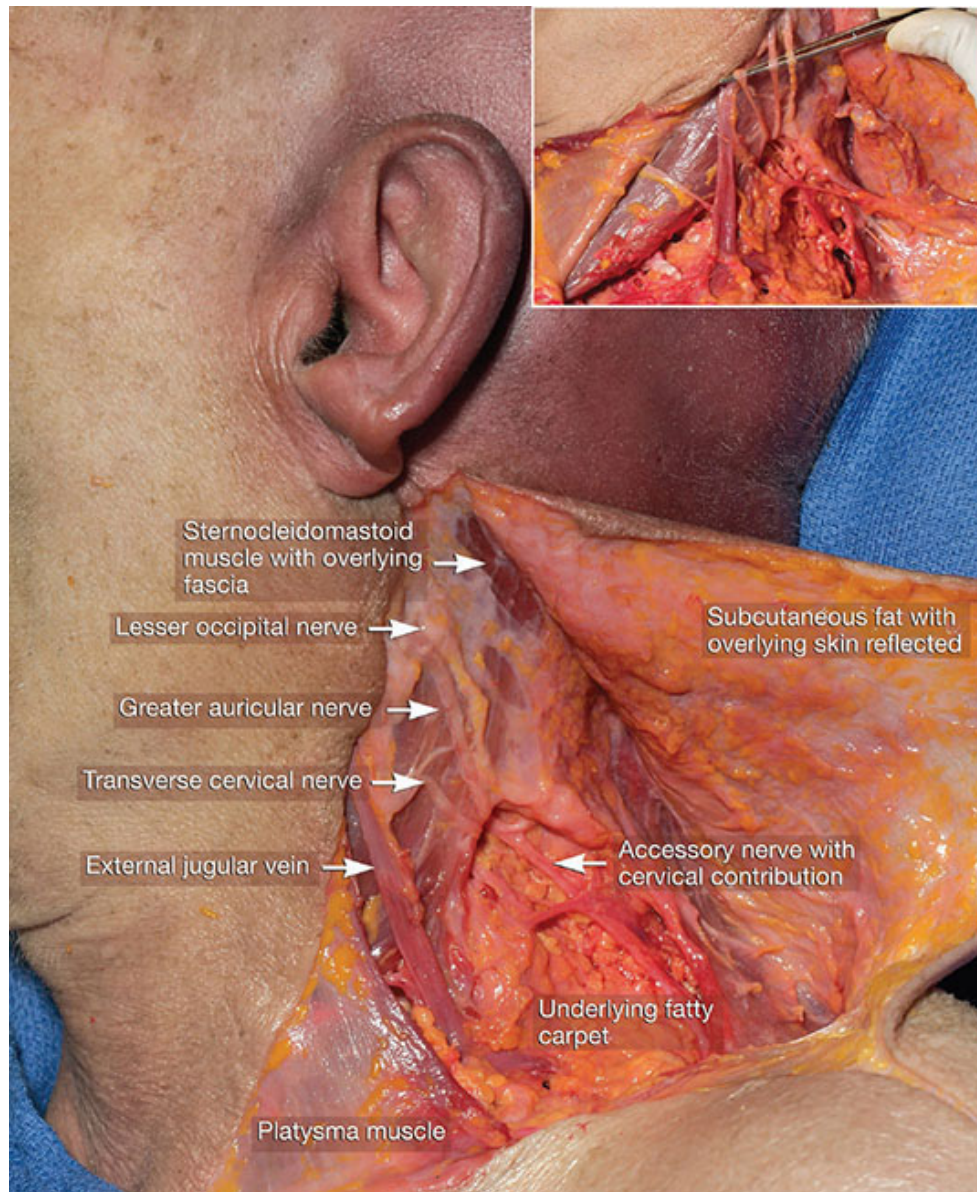


Figure 1-30. Superficial dissection of the posterior triangle of the neck with detailed demonstration of the key regional nerves.

The layered organization of anatomical structures presents access to safe dissection planes. When performing surgery on the neck, appreciating the organization of the fascia allows the surgeon to maintain integral anatomy while safely accessing clinically targeted structures or areas. Fascia of the neck can be differentiated into superficial fascia and deep fascia. The superficial fascia is often synonymous with the subcutaneous tissue, but in the neck, the platysma is contained within it and shares the same relationship that

the muscles of facial expression have with the SMAS. The deep cervical fascia, on the other hand, is further separated into three layers. The superficial layer and deep layer completely surround the neck while the middle layer is discontinuous. The investing layer of deep cervical fascia (superficial) splits to surround the SCM, trapezius, and strap muscles (connecting the sternum to the laryngeal framework). As this layer covers the posterior triangle of the neck, it also forms a fascial layer over the cervical cutaneous and accessory nerves. The deep layer of deep cervical fascia (prevertebral fascia) covers the deeper layer of neck muscles as well as the scalene muscles, thereby also forming the floor of the posterior triangle of the neck (Fig. 1-30). In the posterior triangle of the neck, the deep layer of deep cervical fascia overlays the trunks of the brachial plexus as well as the phrenic nerve which travels on the anterior surface of the anterior scalene muscle (Fig. 1-31). Pretracheal fascia can only be found on the anterior aspect of the neck. It arises from the superficial layer of the deep cervical fascia and overlies the thyroid gland, laryngeal structures, and trachea.

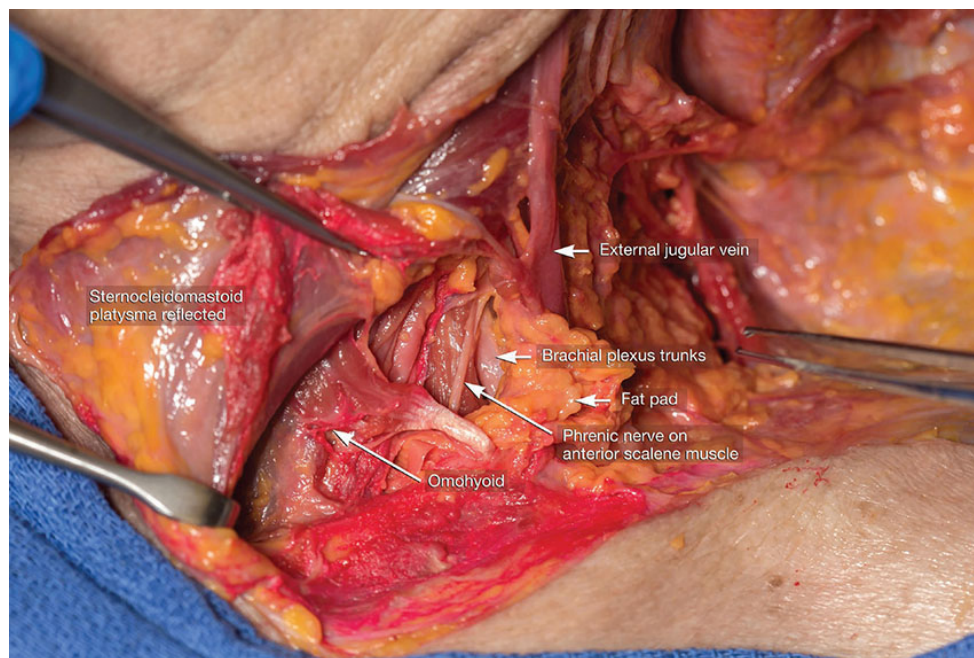


Figure 1-31. Deeper dissection of the posterior triangle demonstrating anatomical structures beneath fatty carpet.

As the plane beneath the platysma is entered, branches of the cervical plexus become distinctly visible. Care should be taken to avoid injury to

these nerves, even though their disruption results in nothing more than loss of cutaneous innervation, possible formation of neuromas must also be considered.

The great auricular nerve (Fig. 1-30) derived from the second and third cervical nerve loops, passes around the SCM almost vertically to the skin of the ear lobe. It can be quite adherent to the overlying fascia and is the largest of the cervical nerves in that region. Additionally, it supplies cutaneous innervation to posterior portion of the ear, inferior parotid, and mastoid areas.

The lesser occipital nerve (Fig. 1-30), also derived from the second and third cervical nerves, passes close to the posterior edge of SCM in a superior trajectory. It innervates the skin behind the ears and parietal scalp.

The transverse cervical nerve (Fig. 1-30) arises from the second and third cervical nerves, and passes horizontally across the SCM. It fans out to supply the skin over the anterior aspect of the neck.

Additionally, the supraclavicular nerves (usually three to four branches) arise from the third and fourth cervical nerves to pass inferiorly and supply skin over the supraclavicular triangle, sternum, deltoid region, lateral clavicle, and upper posterior trapezius area.

CONCLUSIONS

This anatomy discussion is intended to serve as a preoperative review and a conceptual framework for guiding the dermatologic surgeon. The concepts presented are based on reviews regarding clinically significant anatomy as well as established descriptions of normal anatomy, but in particular from recordings of detailed microdissection of a series of latex-injected fresh frozen cadavers. Anatomical descriptions have been designed to specifically enhance perspectives for the dermatologic surgeon in the hope that its understanding will decrease surgical hesitance and promote advances toward better tissue repair. Visualization of a layered system will strengthen the understanding of the course and location of important neurovascular structures as they travel in a stepwise pattern in and between the muscular, bony and fascial planes to reach their terminal areas of supply and innervation. Standard descriptions of the neurovascular distribution and patterns provide a limiting 2D view of structures travelling within a 3D

configuration. Understanding the relative depth, course, and variability of key structures as they traverse anatomical boundaries provides the key to successful surgery.^{6,8,35–43}

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CHAPTER 2 Wound Healing and Surgical Wound Dressings

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SUMMARY

- Acute postsurgical wounds follow an orderly progression in healing, from hemostasis/inflammation to proliferation, and on to maturation and remodeling.
- Minimizing tension during primary wound closure will help limit the proliferative phase of wound healing and decrease chances of keloid formation.

- Simple wound dressings, such as polymer films, are generally adequate for most postoperative wounds.

Beginner Pearls



- Avoid dressing a wound with gauze directly adjacent to the wound bed, as it has a tendency to become incorporated into the wound.
- An ounce of prevention truly is worth a pound of cure; pay attention to meticulous suturing and wound closure, and dressing choice will be far less important.
- Be sure to affix the pressure dressing to the surrounding skin and not to the polymer film, or when the pressure dressing is removed the film will be as well.

Expert Pearls



- While polymer films, such as Tegaderm, may work well for wounds closed with buried sutures alone, nylon sutures that will require removal in under a week may be best dressed with nonadherent pads.

Don't Forget!



- When using a polymer film dressing, some moisture under the dressing is desirable, but excess serous drainage may lead to maceration.
- Most surgical wounds do not require topical antibiotic dressings or ointments.

Pitfalls and Cautions



- Wound debridement is of vital importance, but can be painful. In general, the removal of necrotic tissue is fairly painless, though pretreatment with local anesthetics may be desirable.
- Expensive wound dressings and devices generally add little (other than expense) to the healing of well-sutured operative wounds.

Patient Education Points



- When using clear polymer films, advise patients that they will likely see some serous drainage or even frank bleeding under the dressing. A small amount of eschar present under the film is not concerning.
- Patient education regarding leg elevation and compression after lower leg procedures is of vital importance.

Billing Pearls



- While wound dressings are incorporated as part of any surgical procedure, debridement may be separately billable using the debridement codes (11042 series). Wound debridement performed during the postoperative global period, however, cannot be billed separately.

CHAPTER 2 Wound Healing and Surgical Wound Dressings

INTRODUCTION

Acute wounds are created with every surgical procedure, and outcomes are generally dependent on the wound-healing process. As dermatologic surgery frequently involves cosmetically sensitive areas such as the face, wound healing is of particular importance; even on the trunk and extremities, however, most patients tend to judge the success of their dermatologic surgery procedure more on the basis of the final scar appearance than on the low rate of recurrence.

The healing process is highly dependent on a patient's underlying health status, and complications such as surgical-site infections (SSIs), chronic wound development, and keloid scarring are common. In the United States, over 70 million surgeries are performed a year, with an estimated 38 million patients requiring acute postsurgical wound care.¹ Proper postsurgical wound care is the surgeon's first-line defense against morbidity.

Basic biology of wound healing

Three phases of acute wound healing

The biological process of healing an acute wound is coordinated across many cell types and physiological systems. It is classically described as consisting of three phases: an initial response in which hemostasis and

inflammation dominate, followed by a proliferative phase, followed by a period of maturation and remodeling (Table 2-1).²⁻⁴

Table 2-1. The Acute Wound Healing Process

Hemostasis/ Inflammation	Proliferation	Maturation/ Remodeling
Hours	Days	Weeks

Hemostasis and inflammation. In the initial phase of wound healing, local injury triggers recruitment of inflammatory cells. Wounding is accompanied by vascular injury and exposure of subendothelial collagen, which activates the intrinsic clotting cascade to aggregate platelets and form a fibrin clot. The damaged parenchymal cells and activated platelets then release multiple cytokines and growth factors, including platelet-derived growth factor and TGF- β , which attract inflammatory cells and fibroblasts to the site of injury. The established fibrin clot then serves as a scaffold for recruited cells. Following coagulation, cells migrate to the site of injury in waves. Neutrophils arrive first and play an antimicrobial role, phagocytizing bacteria or other foreign particles. Next, monocytes from the blood stream enter the wound site and are activated by platelet-released factors and the extracellular matrix to release multiple factors necessary for a continued inflammatory response and recruitment of fibroblasts, including CSF-1, TNF- α , PDGF, and nitric oxide.^{5,6}

Proliferation. During the proliferative phase of wound healing, granulation tissue and a new epithelial layer are formed. Granulation tissue begins forming 2 to 4 days after wounding when fibroblasts from neighboring dermal tissue are activated by release of growth factors including PDGF and EGF. These cells replicate and migrate into the matrix produced by the initial clot. Triggered by interactions with the clot, they secrete enzymes that break down the existing matrix and produce type III collagen to build a new matrix. Also during this period, angiogenesis is initiated, stimulated by factors released by macrophages and epidermal cells in response to damage and local hypoxia (Fig. 2-1).

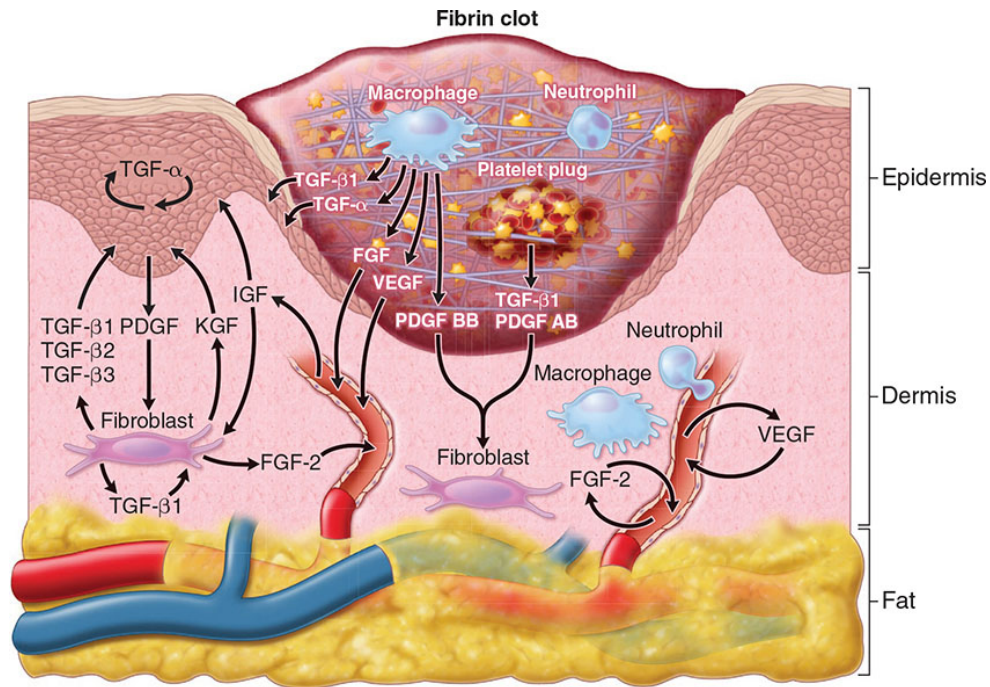


Figure 2-1. Overview of proliferative phase wound-healing activity.

Reepithelialization is initiated soon after wounding when epidermal cells at the wound edge dissolve their basement membrane connections, alter their integrin presentation and cytoskeleton and begin migrating into the wound site, separating the clot products from underlying viable tissue.⁷⁻⁹ Next, the remaining epidermal cells at the wound margin proliferate and migrate over the provisional matrix. Once an intact cell layer is formed by proliferation and migration, basement membrane attachments and integrin expression revert to baseline state.

Maturation and remodeling. For wounds in which the edges were not approximated by external means, a process of wound contracture occurs over 2 to 3 weeks following wounding. This process is mediated both by fibroblasts moving on the collagen matrix and the presence of specialized myofibroblast cells which can be detected beginning 6 days after wounding.¹⁰ After contracture is complete, the wound remains weak, reaching approximately 20% of its final strength.¹¹ Over the next several weeks, the matrix undergoes a slower process of remodeling during which matrix metalloproteinases break down the existing type III collagen ECM and fibroblasts synthesize the stronger type I collagen.¹² By 3 months after

wounding; the scar tissue will reach its maximum strength, around 80% of the tensile strength of normal tissue.¹¹

Factors affecting wound healing

The ability of the carefully orchestrated process of wound healing to proceed in a timely and organized manner is highly dependent on optimal physiologic status. The level of bacteria, moisture balance, and tissue oxygenation, all have large impacts on a wound's ability to heal. Regarding bacteria, it is the level and type of bacterial burden that determines whether infection will spread and inhibit healing. A bacterial load of $>10^5$ per gram of tissue impairs closure regardless of method, as does the presence of any level of beta-hemolytic streptococcus.¹³ When the load is elevated, the inflammatory stage is prolonged and bacteria excrete enzymes that disrupt formation of ECM.

The impact of oxygenation varies throughout healing. While initial localized hypoxia stimulates proliferation, prolonged hypoxia is detrimental, triggering endothelial cell apoptosis and diminishing the essential activity of both neutrophils and fibroblasts.^{14,15} Coupled with the importance of maintaining perfusion, local edema and elevated tissue pressures play a detrimental role in wound healing by creating local ischemia. Pressure-related ischemia is a detrimental factor for healing in patients with low oncotic pressures, with venous-related edema and lymphedema, and in tissues which sustain elevated pressure during activity, such as bony prominences or feet.¹⁶

Evidence has shown that sufficient moisture is also necessary for proper healing. Excessive drying can lead to eschar formation and necrosis, while maintaining a moist environment facilitates the action of cytokines and formation of a preliminary ECM.^{17–19} However, excessive moisture can also be detrimental, leading to maceration of surrounding tissue and preventing appropriate formation of granulation tissue.²⁰

Patient factors

The ability of a wound to heal is strongly affected by the patient's underlying nutritional status, age and health status, and the underlying integrity of the wound site. It is important to consider these factors when evaluating a

patient's potential for healing and need for specialized wound care. Healing-related factors to consider in a patient's initial history and physical are noted in [Table 2-2](#).

Table 2-2. Considerations for Preoperative History and Physical to Predict Wound Healing

Healing-Focused History and Physical
<i>History</i>
Prior surgeries with prolonged healing
Prior keloid scarring
Prior lymph node dissection
Prior radiation
Recent HbA1c
Nutritional history
Use of steroids
Smoking history
Family history of prolonged healing
Dermatologic conditions
<i>Physical</i>
Body mass index
Perfusion distal to wound site
Local edema
Quality of scarring throughout body

Malnutrition has a negative effect on multiple processes of wound healing. The amino acids methionine and arginine are specifically implicated in cellular proliferation, matrix building, and angiogenesis. Multiple trace metals and vitamin C are all implicated in collagen synthesis, supporting the observation that patients with poor nutrition status have lower ability to rebuild an ECM.²¹

Obesity and hyperglycemia are also detrimental to healing. Obese individuals experience a higher rate of wound dehiscence, SSI, and pressure

ulcers,²² attributed to reduced perfusion of adipose tissue and systemic inflammation.^{23,24} Patients with diabetes also have pathologic inflammation in normal tissue, coupled with decreased migration of inflammatory cells, fibroblasts, and keratinocytes impairing progression of wound healing.^{25,26} Many diabetics also have vascular abnormalities leading to impaired delivery of nutrients and oxygen.^{25,27} Recent glycemic status, as measured by HbA1c, is inversely correlated with rate of wound healing.²⁸

Increasing age is associated with characteristic changes in the healing process that result in delayed healing. Delays have been documented in inflammatory response, collagen synthesis, and reepithelialization, along with decreased turnover and remodeling.^{29–31} Much of this change has been linked to changes in sex hormones. Wounds in elderly individuals have altered expression of estrogen-regulated genes and improvement in wound healing is seen with estrogen supplementation in both aged men and women.^{32,33}

Other patient factors that can impair wound healing include cigarette smoking and steroid use (Table 2-3). Cigarette smoking has a major negative impact on wound healing across all demographics, with two pack per day smokers having a six times greater risk of skin graft necrosis than nonsmokers.³⁴ Nicotine decreases proliferation of fibroblasts, macrophages, and endothelial cells and decreases tissue oxygenation.³⁵ Taking systemic glucocorticoid steroids negatively impacts wound healing by decreasing the necessary inflammatory response and decreasing fibroblast response. Wounds heal with incomplete granulation tissue and less contracture.³⁶

Table 2-3. Factors Affecting Wound Healing

Risk Factor	Mechanism
Obesity	Decreased perfusion of adipose tissue and increased inflammation
Malnutrition	Amino acid, vitamin, mineral, and cofactor unavailability
Diabetes	Pathologic inflammation and decreased migration
Age	Decreased estrogen levels
Cigarette smoking	Decreased tissue oxygenation
Steroid use	Decreased inflammatory and fibroblast response

Complicated wound healing

Chronic wounds. Wounds are considered chronic when they fail to heal for more than 42 days or exhibit frequent recurrence in the same location. These are most commonly seen in situations with multiple systemic risk factors for wound healing. Approximately 90% are either pressure ulcers, venous ulcers, or diabetic ulcers, though an estimated 20% of acute wounds with significant tissue loss transition into a chronic pattern, so clinicians working with surgical wounds should be aware of the behavior associated with chronic wounds.^{37,38} Histologically, chronic wounds are associated with increased presence of inflammatory cells and inadequate extracellular matrix formation.³⁹ Derangements in moisture balance, bacterial burden, and perfusion are all implicated in pathogenesis. Exudate from chronic wound shows increased proteolytic activity, degrading growth signals and ECM components.^{40,41} As chronic wounds progress, bacterial burden and necrotic tissue burden increase, stimulating further inflammatory signaling. Significant tissue edema is often present, decreasing perfusion and inhibiting wound healing.³⁷

Keloid scarring. Keloid scars arise when the proliferative phase of wound healing is prolonged, without appropriate negative feedback and remodeling. These scars grow outside the initial margin of the wound, can become large, and are often associated with pain, pressure, and pruritus. They do not spontaneously regress. Histologically, these have few organized

bundles of collagen, with unorganized deposition of both collagen type I and type III.^{42,43} The likelihood of a patient forming keloid scars after wounding appears to have a strong genetic contribution and is particularly enriched within the African American population.^{44,45} The altered pathophysiology underlying keloid scarring centers on overactivation of fibroblasts in the proliferative stage. This is thought to be mediated by TGF- β and PDGF signaling,^{46,47} as well as increased VEGF signaling from keratinocytes overlying the scar.^{48,49} Recent work shows increased fibroblast activation and inflammation may also be due to the effects of tension on a healing wound, mediated by fibroblast focal adhesion kinase (FAK) mechanotransduction.⁵⁰

CLINICAL IMPLICATIONS

While many factors affecting healing may be out of the surgeon's control at the time of a procedure, a clinician can have a large impact on healing outcome through appropriate wound care including closure design and tension minimization, management of bacterial burden, wound dressing, and monitoring. The proper choices for each of these parameters depend largely on the type and location of the initial wound.

Wound closure

The main types of closure used in dermatologic surgery are primary closure and closure by secondary intention. For primary closure, the dermis is approximated immediately after a procedure. For closure by secondary intention, a wound is left open to heal spontaneously. Delayed primary closure refers to leaving a wound open for initial care and approximating the dermal edges at a later time.

Primary closure utilizing sutures, staples, or surgical glue is the first choice for wounds that are clean and have sufficient tissue for approximation. For these wounds, the processes of reepithelialization and wound contracture are less necessary for healing. This method often requires the least complex wound care, and heals more quickly and with less pain. Wounds closed in this manner have reduced scarring.⁵¹

Closure by secondary intention is appropriate for most wounds that do not meet criteria for primary closure or grafting, such as contaminated wounds or those with significant tissue destruction, or in cases where shallow wounds would be expected to heal fairly quickly. This process often requires more involved care during the healing process. While it is generally thought that healing by secondary intention is more likely to leave a prominent scar, cosmetically favorable healing through secondary intention has been reported in many instances, particularly on concave body surfaces such as the nasolabial fold, canthus, ears, and temples.^{51,52}

Hemostasis

Hemostasis is essential for wound healing, as the activation of the coagulation cascade and formation of a clot play an essential role in initiating the healing cascade. While hemostasis is an important goal at the end of surgery, some bleeding at the time of dressing and wound care is frequently seen. The main options for hemostasis in open or actively bleeding small wounds are caustic agents, physical agents, and physiological agents. Caustic agents include aluminum chloride, ferric sulfate, silver nitrate, and zinc chloride. These work by local tissue destruction, initiating coagulation and forming a small eschar. Aluminum chloride is most commonly used, and is desirable because it does not leave residual skin pigmentation. Noncaustic agents include physical agents, gelatin, cellulose, p-GlcNAc, and microfibrillar collagen, which promote clot formation by forming a mesh for further clotting. These approaches may promote a granulomatous foreign-body reaction so they should be avoided in settings of infection, or near the eyes in particular. Physiological agents include epinephrine and cocaine, which induce vasoconstriction, as well as topical thrombin, fibrin sealant, or platelet gels.⁵³

Management of bacterial burden

SSIs are generally uncommon in dermatologic surgery, and their frequency can range from 3% to 28% depending on the body site involved. SSIs are more frequently seen in the distal lower extremities.⁵⁴ The most commonly isolated organism in SSIs is *Staphylococcus aureus*, much of which is from

an endogenous origin.⁵⁵ The skin resident *Staphylococcus epidermidis* can also lead to pathogenic infection when it adopts different virulence factors.⁵⁶ Though less common, wound infections with gram-negative bacteria and *beta-hemolytic streptococci* are observed, often in the lower extremities, and can be particularly destructive.

The majority of dermatologic surgeries do not require systemic antibiotic prophylaxis unless the wound appears dirty or the patient has a particularly high risk for infection.⁵⁷ If prophylaxis is desired because of patient risk factors or wound location, a single preoperative dose is recommended. If the wound does appear infected or dirty, a 7- to 10-day course of systemic antibiotics is merited. Antibiotics should be chosen based on suspected pathogen.⁵⁷ Antibiotic choices and protocols are discussed in detail in [Chapter 7](#).

If a wound appears heavily contaminated or has a large burden of devitalized tissue that may serve as a nidus for infection, it is important to remove as much of this as possible by debriding the wound before dressing. There are multiple options for debridement. The first-line option, sharp debridement, involves use of instruments to remove material with local anesthetic. It is most effective and targeted, but can be painful and is not always well tolerated. Other options include autolytic debridement, in which a moist environment is created to facilitate digestion of necrotic tissue by endogenous enzymes, or enzymatic debridement using laboratory-produced collagenase or papain. Autolytic debridement carries a risk of overhydration and maceration, while enzymatic debridement is expensive and thus not a first-line choice. Surgical debridement under anesthesia may be performed as well, while recently other options, such as cold helium plasma with radiofrequency, have been explored as well.⁵⁸ Hydrosurgery offers a less damaging option in which a saline beam is applied tangentially to the wound, but also requires anesthesia and is not widely available.⁵⁹

Wound dressings

Once hemostasis is achieved and bacterial burden is managed, the clinician must decide whether to dress a wound, and, if dressing is desired, what type to use. Dressings can serve multiple functions including protection, hemostasis, compression, and moisture regulation. However, the time spent

changing dressings and cost of advanced dressings must be weighed against their benefit in each circumstance. For acute surgical wounds closed by primary intention without infection or excess exudate, there is no evidence that use of a dressing or choice of specific dressing has an impact on time of healing, prevention of infection, pain, or scarring.⁶⁰ Given the role of tension in scarring and fibrosis, novel dressings, which externally reduce tension, may show potential for decreasing scarring, though these benefits may be nonexistent if a wound is well sutured with minimal tension.⁶¹ Cost and ease of use should always be considered when deciding on dressing choice.

For wounds healing by secondary intention, the level of bacterial burden, amount of exudate, and patient preference guide dressing choice. Dressings vary based on degree of occlusion, permeability/moisture, absorption, adherence, compression, and maintenance involved.

Antimicrobial dressings

The use of local antimicrobials following a procedure is not recommended for general prevention of SSIs. They are no more effective at preventing SSIs than petroleum, and topical antibiotics can increase the frequency of resistant organisms within a wound.^{62,63} If a local antimicrobial is desired due to risk of local infection, iodine- or silver-based solutions or dressings are often chosen because they provide broad coverage and are associated with lower levels of bacterial resistance than topical antibiotic ointments. Iodine-based options include povidone-iodine, available as an impregnated tulle, or cadexomer iodine, a starch which absorbs fluid while slowly releasing iodine, and is useful for exudative wounds. These should not be used in patients with thyroid conditions due to low levels of systemic absorption. Silver-based antimicrobials are available as a topical cream (silver sulfadiazine) or impregnated in a variety of dressings, including foam, gauze, and nanocrystalline preparations for slow release. Silver sulfadiazine cream is less favorable for use in most settings because it stains skin and forms a pseudo-eschar. Specific silver-impregnated dressings should be chosen based on other desired dressing properties (Fig. 2-2). On a practical level, many dermatologic surgeons utilize mupirocin ointment as an antibacterial ointment of choice, though contact allergy and even anaphylaxis have been reported.

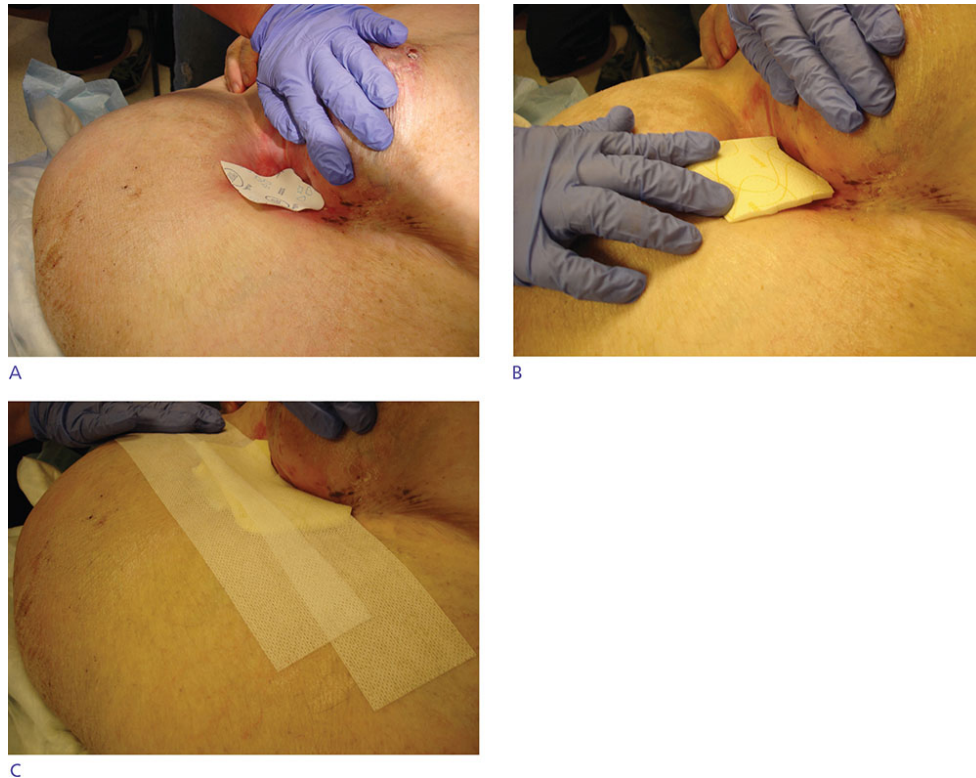


Figure 2-2. Silver and absorbent foam dressing for exudative wound in high-pressure region. (A) The wound is covered with nonadherent, silver-impregnated dressing. (B) The silver dressing is covered in occlusive foam layer for padding and absorption. (C) The layers of dressing are secured with adhesive.

Occlusive dressings

Given the importance of maintaining a moist and relatively sterile environment for healing, occlusive dressings are the first choice for noninfected, nonischemic wounds. These dressings maintain a moist environment preventing drying and eschar formation, which are detrimental for reepithelialization. As compared to basic gauze dressings, occlusive dressings increase reepithelialization and collagenization and decrease rates of SSIs.^{19,64,65} Occlusive dressings range widely in their indications, degree of permeability to air and water, level of fluid absorbency and adherence (Table 2-4).

Table 2-4. Types and Properties of Occlusive Dressings

Type	Characteristics	Advantages	Disadvantages	Indications	Maintenance
Hydrogels	Semipermeable, nonadherent	Pain relief, nontraumatic removal, allows autolytic debridement	Risk of infection, may overhydrate	Dry, painful wounds	Change every 1–3 days
Polymer films	Transparent, Semiocclusive, adherent	Protects from infection	Fluid trapping, can strip skin	Wounds with little exudate, closed wounds	Leave in place 7 days or until fluid leaks
Hydrocolloids	Opaque, impermeable, adherent, absorbent, occlusive	Protects from infection, allows autolytic debridement	Malodorous discharge, fluid trapping/can overhydrate	Low exudate	Leave in place 7 days or until fluid leaks
Polymer foams	Opaque, absorbent, occlusive, nonadherent	Cut to shape, thermal insulation	Can be incorporated into wound if dry	Light to moderate exudate, sloughy wounds	Must change every 3 days or incorporated into wound
Alginates	Nonadherent, highly absorbent, hemostatic	Helpful in hemostasis	Malodorous	Wounds with heavy exudate or moderate bleeding	Change when soaked in exudate

Polymer films such as Tegaderm and Opsite, represent the classic occlusive dressings. These adhere to healthy skin, but not to the wound site. They are semipermeable, allowing air and water vapor exchange, and they are clear, allowing visual monitoring of the wound. These provide no cushioning or absorbency so they are appropriate for shallow wounds with low exudate only, such as those seen in most surgical site repairs. **Polymer foams**, such as Allevyn and Lyofoam, consist of an absorbent surface in contact with a semipermeable backing to prevent leakage. These are appropriate for heavily exudative wounds. They are nonadherent and require another layer of dressing (Fig. 2-2B). **Hydrocolloids**, including Exuderm, Duoderm, and Comfeel, consist of multiple layers. When placed on a wound, the bottom layer forms a gel. This moisturizes the wound bed, promoting autolytic debridement. The top layer is adherent and virtually impermeable, providing protection to the wound during daily activity. **Hydrogels**, such as Restore-hydrogel, SAF-Gel and CuraGel, consist of a matrix of insoluble polymers and water, allowing them to both donate moisture to a dry wound surface and absorb wound exudate. They are commonly used to promote autolytic debridement. **Alginates**, including Sorbsan and Kaltostat, are produced from salts of alginic acid found in brown seaweed. These dressings partially dissolve upon contact with a wound bed when sodium ions from the wound are exchanged with calcium ions from the dressing, forming a highly absorptive gel appropriate for wounds with high levels of exudate (Fig. 2-3).



Figure 2-3. Alginate dressing for bleeding, exudative wound. (A) Alginate dressing is applied and binds to wound site. (B) Adherent gauze is used to secure and protect alginate.

Specific indications and restrictions of each type of occlusive dressing are detailed further in [Table 2-5](#).

Table 2-5. Dressing Choice Based on Wound Characteristics

Wound Characteristics	Dressings to Consider
<i>Primarily closed</i>	Polymer film or petroleum
<i>Dry, necrotic</i>	Hydrogel or hydrocolloid, debride when hydrated
<i>Sloughing</i>	Debridement, cadexomer iodine or silver-based dressing
Shallow	Hydrocolloid
With exudate	Alginate
<i>Deep, nongranulating</i>	Synthetic dermal matrix or bilayer
<i>Red, granulating</i>	
Wounds with deep sinuses	Alginate ribbon or hydrogel
Deep cavity	Foam, foam in plastic pouch
Shallow, heavy exudate	Alginate sheet
Shallow mild exudate	Foam
Shallow nonexudative	Hydrocolloid
<i>Pink, epithelializing</i>	
Heavy exudate	Alginate
Mild exudate	Hydrocolloid
Nonexudative	Film
<i>Infected</i>	
Heavy exudate	Negative-pressure wound therapy, hydroconductive dressing
Mild exudate	Silver or iodine based dressing
<i>Edematous</i>	Compressive dressing
<i>Ischemic</i>	Hyperbaric oxygen therapy

Absorptive dressing

While research favors dressings that maintain local moisture in most settings, absorptive dressings are indicated in settings where excessive exudate is

problematic, such as primarily closed wounds with excess drainage or chronic wounds in which exudate can be destructive. While gauze is the classic absorptive dressing, it has been shown to be a poor barrier against bacteria, and it is frequently incorporated into wound beds, disrupting formation of granulation tissue when removed.⁶⁶ Recent alternatives include the layered hydroconductive dressings, in which a bottom layer wicks moisture out of the wound bed (Fig. 2-4). These dressings are effective at removing both moisture and debris, contributing to a reduced bioburden in contaminated wounds.⁶⁷

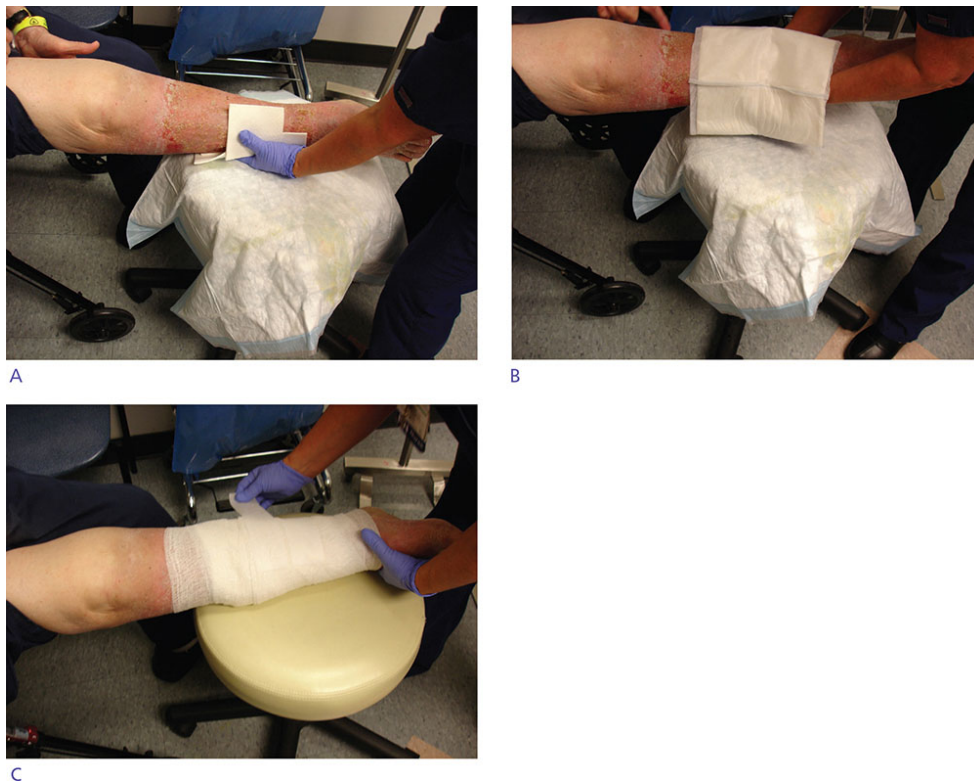


Figure 2-4. Hydroconductive dressing for exudative wound. (A) Following debridement, hydroconductive dressing is applied over wound bed. (B) An abdominal pad is applied over dressing for additional absorption and padding. (C) Dressing is secured in place.

Compressive dressing

Dressings that provide compression are useful when edema prevents healing. Though most studies of compression have focused on chronic wounds, edema also interferes with healing of acute surgical wounds, most commonly those

in the lower extremities. The benefits of compressive dressing have been demonstrated for acute healing of excisional wounds in the lower extremities healing by secondary intention.⁶⁸ The classical compression dressing is the Unna wrap, a zinc oxide compression dressing. However, this dressing can be uncomfortable and restrict motion. Over the past decade, multiple commercial alternatives have arisen providing varying levels of customization that have been shown to be equally effective to the Unna wrap in promoting healing, though can require training for patients to manage (Figs. 2-5 and 2-6).^{19,69}

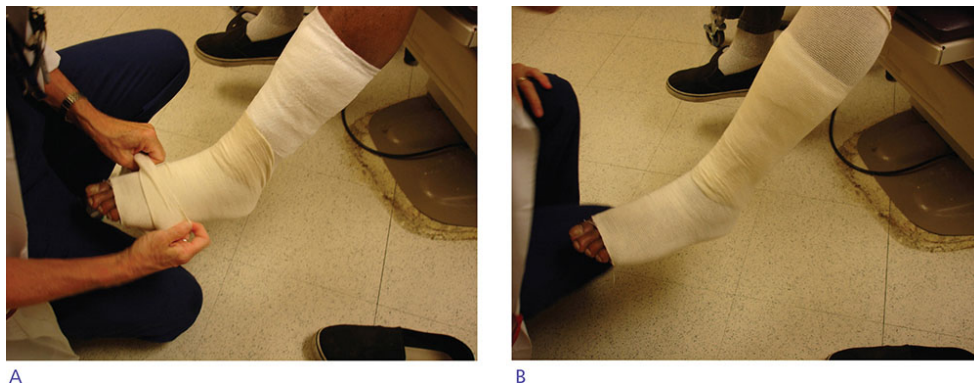


Figure 2-5. Tubular elastic compression to promote healing of lower extremity wound. (A) After wound is dressed and covered, tubular elastic is applied. (B) Elastic extends up to knee level.



Figure 2-6. Absorptive dressing and two-step elastic compression for exudative wound in edematous leg. (A) Exudative wound is wrapped in hydroconductive dressing for absorption of exudate. (B) First layer of Coban™ 2-layer elastic dressing is applied over dressing. (C) Second layer of Coban™ 2-layer elastic dressing is applied and secured.

Wound-healing adjuncts

For many acute surgical wounds, achieving hemostasis, managing bacterial burden, appropriate closure, and dressing will be sufficient to achieve a favorable healing outcome. However, up to 20% of acute surgical wounds with significant tissue loss become chronic, and this is more likely when working with patients whose physiology is not optimal for healing.³⁸ When working with a wound with a low likelihood of healing, incorporating additional healing adjuncts can have significant benefits. These include the use of synthetic skin substitutes, negative-pressure therapy, hyperbaric oxygen therapy, and synthetic growth factors to promote wound closure in the acute period.

Synthetic skin substitutes

Because of the difficulties obtaining sufficient tissue for autologous grafts, synthetic alternatives have been developed to close large wounds without requiring living tissue transplantation. Synthetics can be cellular or acellular and can be single layer (dermal or epidermal) or bilayer. Single-layer synthetic epidermal grafts generally consist of autologous keratinocytes expanded in culture, which are laid over a wound bed to reepithelize and provide protection, usually as a local specialized service to select burn hospitals. This process is time consuming and the effective uptake of these grafts varies widely. Currently, an entire body surface area worth of epidermis can be grown from a 3 cm² biopsy, and novel methods of delivery of allogeneic cells, ranging from impregnated matrices to aerosolized cells, are in development to improve incorporation.^{70,71}

For wounds that have significant loss of dermal matrix, synthetics involving dermal substitutes can provide a matrix for cellular migration/growth. These matrices allow infiltration of fibroblasts, angiogenesis, and eventually can provide a scaffold for reepithelialization. The most common of these are collagen-based dressings. These can be decellularized bovine or laboratory-generated matrices, or solubilized collagen repolymerized into fibers, films, or sponges. Cellular alternatives, such as Dermagraft, consist of neonatal fibroblasts cultured on a bioabsorbable mesh to synthesize a physiologic dermis. These are more effective at stimulating a healing response than acellular layers and have outcomes comparable to allograft.^{72,73} These matrices promote hemostasis and fibroblast proliferation and can provide a base for reepithelialization, though they do not offer the protection of an epidermal layer.

Other physiological skin substitutes consist of bilayered scaffolds, which can be acellular or cellular. With Integra, an acellular bilayer system, a silicone epidermal substitute is initially placed over an artificial dermal collagen matrix. After the dermal matrix is infiltrated and vascularized, the silicone layer is removed and replaced with epidermal grafts.⁷⁴ This system has favorable reconstructive and cosmetic outcomes, often with greater patient satisfaction than autologous grafting.⁷⁵ Apligraf, a cellular bilayer, consists of neonatal keratinocytes and fibroblasts grown on a bovine collagen matrix. It decreases healing times when used as an adjunct to autografts or alone on chronic wounds,^{76,77} though it has a very short shelf life and its significant expense may limit its use.

Negative-pressure therapy

For wounds healing by secondary intention or delayed primary closure for which excessive exudate, infection, or inflammation inhibit healing, negative-pressure therapy is an option for management. These systems apply negative-pressure suction through a sealed wound dressing by way of a pump. These pumps can be large and stationary for inpatient use or small and portable for long-term outpatient use. The use of negative pressure significantly decreases edema and exudate and stimulates both fibroblast migration and contraction.^{78,79} This method has been clearly established to improve outcomes in chronic wounds⁸⁰; however, the benefit is less clear for acute wounds healing by secondary intention or delayed primary closure.^{81,82} This should be considered in acute wounds with a large amount of exudate to promote healing by secondary intention or prepare for delayed primary closure.

Hyperbaric oxygen therapy

Hyperbaric oxygen therapy involves delivery of 100% oxygen at a pressure above one atmosphere to the wound site. This is performed using hyperbaric oxygen chambers and is dependent on availability of chambers. It has been shown to significantly increase the amount of oxygen available to skin and promote wound healing, particularly in settings where healing is impaired by poor local blood supply or damage to the vasculature, as seen in chronic venous or diabetic ulcers.⁸³ While less widely used, this therapy significantly increases uptake of split-thickness grafts, uptake of compromised flaps, healing of previously irradiated tissue, and healing of acute wounds such as burns and crush injuries therapy.⁸⁴ If available, this should be considered if oxygenation is a limiting factor in healing of an acute wound.

Long-term monitoring

Most dermatologic surgery wounds will be followed in the outpatient setting; therefore, instructing patients in proper wound care is essential for optimal healing. Patients with wounds closed primarily should not shower for the first 48 hours, and avoid baths or showers greater than 10 minutes throughout

healing. Patients with wounds requiring complex dressing should cover dressings with a water impermeable barrier during bathing. Patients with superficial wounds should avoid direct UV exposure to the wound during healing, because exposure may increase the risk of hyperpigmentation.⁸⁵

Throughout the healing process, clinicians should monitor for evidence of nascent infection and wound dehiscence. If signs of acute infection such as increased purulent discharge, erythema, or warmth are present, wounds should be swabbed and cultured. Empiric topical or systemic antibiotics should be initiated, and mechanical, surgical, or autolytic debridement should be performed based on the extent of infection. If superficial wound dehiscence develops in a primarily closed surgical wound, debridement of necrotic tissue should be performed. Following this, wounds with only superficial dehiscence can be left to close by secondary intention, while those with larger dehiscence should be addressed with negative pressure dressing or tension-relieving approaches such as tape, glue, or sutures.⁸⁶

CONCLUSIONS

Wound care and dressing choice play an important role in dermatologic surgery, because even the best-designed closure can be undone by less-than-optimal wound care. Patient education is of paramount importance, because even a fully healed wound will only retain 80% of the tensile strength of its preinjury period. Wound dressing choice following an uncomplicated surgical procedure should be kept as straightforward as possible. For sutured wounds repaired with absorbable sutures alone, using a simple polymer film dressing may allow the patient to return quickly to his or her normal activities and concomitantly minimize the need for re-dressing at home.

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CHAPTER 3 Preoperative Evaluation, Patient Preparation, and Informed Consent

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SUMMARY

- Preoperative preparation should include a discussion regarding the procedure; a review of the patient's history, medications, and allergies; any appropriate physical examination; obtaining informed consent through a process; and answering patient and/or family questions.
- The preoperative evaluation ultimately serves as a forum to assess probability of overall success and cement the patient–physician relationship.

Beginner Pearls



- From the first moment the patient steps into the office, the front office staff has the opportunity to begin collecting information, such as the patient's mood and degree of anxiety.
- If capacity is ever in question, simple questions like “where do you live?” or “how did you get here?” are innocuous queries that evaluate mental status without prompting any perceived stigmatization.

Expert Pearls



- Outline postoperative restrictions ahead of the procedure so that patients avoid conflicts with athletic events as well as allowing them to make any arrangements they may need for home care, child care, time off from work, or transportation to and from the procedure.
- Patient preparation and the informed consent process is a critical part of the surgical procedure.

Don't Forget!



- While a written signature is desirable, the real goal of the consent process is effective communication.
- If an informational packet is provided to help patients prepare, it may include an outline helping them prepare for the pre- and postoperative period.

Pitfalls and Cautions



- Patients who have many questions or voice cosmetic concerns when they are scheduling their procedure are self-identifying as individuals who would benefit from an in-office preoperative consultation.

Patient Education Points



- Without adequate preparation, even mild and expected outcomes, such as edema and ecchymoses, can be a cause for significant concern.
- Make the patient your partner, and use partnering language when discussing the surgical plan.
- Certain subtleties become evident over time, such as personality, forgetfulness, unrealistic expectations, or specific fears that can be noted by the staff and guide the remainder of the visit. These observations can be acted upon early and preemptively, helping to tailor the patient care experience in a positive fashion.
- Some patients under 18 may look older than they are (and vice versa), so it is important when operating on young adults to check their date of birth.
- A full discussion of benefits and risks improves mutual trust and respect between the physician and patient, and ultimately improves patient satisfaction.

CHAPTER 3 Preoperative Evaluation, Patient Preparation, and Informed Consent

INTRODUCTION

Evaluating the patient preoperatively, preparing them for surgery, and going through the informed consent process are important prerequisites that must be accomplished prior to initiating dermatologic surgery. This is important from an ethical standpoint, but also ultimately yields significant time savings for the surgeon, as an informed patient ultimately is less likely to make repeated telephone calls or return visits to the office in the postoperative period. Discussing procedural risks and the possible need for additional surgery or procedures in the postoperative period is always wise, as forewarning and educating patients creates a team atmosphere that ultimately pays significant dividends.

PREOPERATIVE EVALUATION

The preoperative evaluation is most simply thought of as an evaluation of the physical, medical, and emotional preparedness of the patient for a selected procedure. This formal evaluation is generally a multifaceted discussion regarding the procedure; a review of the patient's history, medications, and allergies; any appropriate physical examination; obtaining informed consent through a process; and answering patient and/or family questions. The

evaluation can be performed up to several weeks in advance of the surgery, though it may also take place on the same day of the procedure. If a same-day evaluation is chosen, the physician must be prepared to cancel the procedure if it is discovered the operation scheduled is inappropriate for the lesion, or the patient is not a good surgical candidate for medical or psychological reasons. There are many factors that should be taken into account when deciding upon the timing of this evaluation including office setup, physician preference, patient mobility, and travel distance. Nevertheless, the preoperative evaluation ultimately serves as a forum to assess probability of overall success and cement the patient–physician relationship.

Team care is a critical component of the preoperative evaluation. It begins with the very first patient contact and continues up to the initiation of the procedure itself. All members of the team should be empowered and encouraged to have input in this evaluation and have the authority to halt it for any concerns. From the first moment the patient steps into the office, the front office staff has the opportunity to begin collecting information, such as the patient’s mood and degree of anxiety. The medical assistants and nursing staff carry this process forward, with obtaining a history, complete medication list, and any other standard data points necessary for the field of practice.

Certain subtleties become evident over time, such as personality, forgetfulness, unrealistic expectations, or specific fears that can be noted by the staff and guide the remainder of the visit. These observations can be acted upon early and preemptively, helping to tailor the patient care experience in a positive fashion. Moreover, these initial encounters should serve as a filter for red flags like abnormal labs or vital signs, concerning new symptoms, or patient aggression/combativeness. Safety is the responsibility of the team, and the surgeon, as team leader, must use all information gathered to determine the safest way forward. Overall, the guiding principle is that every person of the care team plays an essential role in the overall patient evaluation and experience. [Table 3-1](#) is a summary of possible reasons for delaying a procedure.

Table 3-1. Reasons to Delay Surgery

Psychological

1. Evidence of medication or drug use that impairs judgment
2. Unavailability of health care proxy or guardian when patient is incompetent
3. Indication that the patient does not understand the procedure (negating informed consent)
4. Unrealistic expectations
5. Hostility/anger
6. Evidence of alcohol ingestion/intoxication

Physical Examination

1. Unstable medical condition
 - a. Extreme hypertension
 - b. New or symptomatic cardiac arrhythmia
2. Fever
3. Acute illness
4. Angina/unstable angina
5. Infection/cellulitis of biopsy site
6. Suggestion of boney involvement

Laboratory Examination

1. INR >3.5
2. Thrombocytopenia
3. Metabolic involvement
4. Hypoxia

Miscellaneous

1. Pathology and clinical evaluation do not match
2. Unaccompanied minor without a pre-signed consent form

Patient capacity

Establishing patient decision-making capacity is a cornerstone of the informed consent process and the overall preoperative evaluation. Obtaining an adequate history and providing postoperative instructions is not possible without a patient's ability to accurately understand and make medical decisions on their own behalf. For the vast majority of patients, this is not a problem, but for a few patients, the ability to understand is a significant and delicate issue. Culturally, a stigma is often associated with mental incompetence, and questioning an elderly patient's abilities can interfere with rapport, potentially making them angry or defensive. Furthermore, those with functional impairments may hide their diminished capacity well. It is important to understand that competence is a legal term, which is commonly confused with capacity—a physician assessment. For informed consent, a patient must be capable of understanding the procedure and relevant information, making a rational choice, and understanding any potential complications or consequences. A patient's family can provide significant insight into capacity and/or competency status. Oftentimes, the family may be quick to provide information that the patient requires a co-signer or legal guardian present for paperwork, which makes the process straightforward. The dynamics between the patient and their family may also hint at capacity; repeating instructions in different wording, family leading the conversation, and visible frustration may be cues that suggest the need for a more thorough mental status examination. If unaccompanied, the physician should pay close attention to the patient's general hygiene, coordination, and speech patterns. If ever in question, simple questions like "where do you live?" or "how did you get here?" are innocuous queries that evaluate mental status without prompting any perceived stigmatization.

During the initial evaluation, it is important for all members of the team to quickly assess the patient's overall state of mind. Are they anxious? Confident? Overly worried about cosmetic appearance? With this information, the best support can be offered by the team. Indeed, adequate psychological support cannot be overemphasized for a smooth and successful outcome.

Of course, minors cannot provide true consent for any procedure, though their assent is important. Some patients under 18 may look older than they are (and vice versa), so it is important when operating on young adults to check their date of birth. Be sure any child's parent or legal guardian gives the

consent. This can generally be performed with a phone consent as long as it is witnessed by having a staff member join on the phone to verify the consent.

HISTORY REVIEW

A standard review of medications, allergies, and past medical history must be obtained for every preoperative evaluation. In particular, the presence of a pacemaker, defibrillator, or the use of anticoagulation may impact surgical decision making and techniques, including the type of electrosurgery used, the type of closure chosen, or the type of dressing applied. A history of smoking portends poor wound healing, making a large flap or graft less desirable due to higher risk of failure. A history of alcohol or other substance abuse carries risks of poor wound healing, bleeding, and possible poor compliance with postoperative instructions. A history of radiation treatment to the surgical area increases risks of poor wound healing and tissue mobility. Any positive history should best be shared with the entire team for planning and implementation of the safest care.

Physical examination

Vital signs, including blood pressure, pulse, and respiration rate, are sometimes performed prior to procedures, though doing so is not a standard of care for outpatient dermatologic surgery procedures. Elevated blood pressure is common preprocedurally, and oftentimes is secondary to anxiety or exertion. Repeat measurements are imperative to better delineate “white coat hypertension” or exertional hypertension from more ominous conditions such as hypertensive urgency or emergency. Often, patients may abstain from their antihypertensive medications prior to surgery under the misconception that these are anticoagulants. If the patient has their medication with them, the physician may consider having them take their scheduled dose and re-evaluating after 15 to 20 minutes. Hypertensive urgency is defined as blood pressure >180 mm Hg systolic and >120 mm Hg diastolic in the absence of an acute stressor. A careful review of systems for end-organ damage is necessary, and consideration of procedure abortion and referral to the emergency department is paramount.

Pulse must be evaluated for rate and regularity. Arrhythmias, like atrial fibrillation, are not uncommon in those on anticoagulants, and a determination of whether such an arrhythmia is well controlled must be made prior to surgery. New or symptomatic arrhythmia is a cause for abortion of the procedure and referral to the emergency department.

Any patient showing outward signs of other concerning and acute medical processes, such as shortness of breath, chest pain, or acute neurologic deficit, should be referred to the ED immediately.

PATIENT PREPARATION FOR SURGERY

Cognitively preparing patients for surgery helps create a more positive experience for both patient and surgeon. This preparation includes elements of informed consent, but extends beyond the legal requirements to include patient education about all elements of the procedure from the preoperative to postoperative periods.

Preoperative consultation is one option for cognitively preparing patients for surgery. A clinic visit allows the patient to meet their surgeon in advance and discuss all elements of the procedure in detail ahead of time. This is particularly beneficial for planning very complex surgical procedures, or with anxious patients or patients having surgery for the first time. When the patient is a child or developmentally delayed adult, preoperative consultation with both the patient and parent or legal guardian present allows proper selection of anesthesia. After a full discussion of the procedure, both the surgeon and parent/guardian determine whether local infiltrative anesthesia alone is appropriate, or whether the addition of a topical anesthetic, an oral anxiolytic, sedation, or general anesthesia is required to safely and comfortably perform the necessary procedure. This discussion is often helpful for extremely anxious patients as well, who may benefit from an oral anxiolytic such as lorazepam. Obtaining informed consent at the time of preoperative consultation allows the patient to take an anxiolytic prior to surgery, significantly improving the anxious patient's surgical experience. Patients taking anxiolytics should be directed to have someone drive them to and from their surgery. Such preoperative consultations can occur by telephone if in person consultation is not feasible.

Providing patients with an informational packet either by mail or e-mail is a simple and effective way to review the most important elements of surgery. Outlining any restrictions on activities (bending, lifting, housework, sports) as well as the likely duration of these restrictions ahead of time may help patients avoid conflicts with athletic events as well as allowing them to make any arrangements they may need for home care, child care, time off from work, or transportation to and from the procedure. The potential timing for follow-up visits should be mentioned as well to prevent patients from scheduling surgery immediately before leaving on a trip (unless proper follow-up can be arranged with another provider or is not needed).

If an informational packet is provided to help patients prepare, it may include an outline helping them prepare for the pre- and postoperative period.

During the preoperative consultation, or immediately preceding surgery, a full discussion of the proposed procedure, including the risks and benefits, should be discussed. This is largely part of the informed consent process, and is critical in preparing a patient for their surgery. Reviewing all other reasonable treatment alternatives and the risks and benefits of these treatment options will help patients identify the best option for them.

Once the treatment modality has been selected, the patient will be best prepared if they are walked through the procedure starting with a description of how they will be positioned, how the site will be prepped and draped, and the use of anesthesia. If an excisional procedure such as an excision or Mohs surgery is planned, discussion of possible closures (secondary intention, linear closure, flap or graft, or two-staged closure, if this is anticipated) and potential shape and length of the scar line can be reviewed at this time. Patients are often very concerned about how “long” their scar will be. This is an excellent opportunity to educate patients about the cosmetic principles utilized in designing linear excisions, flaps, and grafts, and discussing the role of hiding incision and scar lines within relaxed skin tension lines and cosmetic boundaries. Understanding that the length of the incision is far less important than the contour and placement of the incision lines, and the preservation of symmetry and free margins, helps both prepare the patient for surgery and instill confidence that their surgeon has expertise in the area of wound reconstruction. In a procedure such as Mohs surgery, where the degree of needed reconstruction cannot always be predicted ahead of time,

patients should be informed of possible closures, and a more detailed discussion can be held at the time of reconstruction.

Sample educational handout outline for preoperative preparation

- Preparing for surgery
 - Avoid nonessential aspirin (patients should check with their PCP prior to stopping ASA)
 - Avoid ibuprofen and other NSAIDs for at least 24 hours before surgery if possible
 - No alcohol for 24 hours before surgery
- Detailed description of the surgery
 - For more complex procedures such as Mohs surgery, a very detailed description of the procedure can be included
- On the day of surgery
 - Shower/wash the surgical site with soap and water
 - Do not wear make-up or jewelry on or near the surgery site
 - Avoid perfume, avoid hair products if the surgical site is the scalp (many hair products are flammable when in contact with cautery)
 - Do not eat or drink anything after midnight, the night before (if going to the OR)
 - Take all of your regular medications (include any exceptions)
 - Inform patients what to bring with them (e.g., book, tablet device, friend, snacks), if this is permitted
- What to expect after surgery
 - Activity limitations
 - Alcohol, medication restrictions
 - Wound care instructions will be given after surgery
 - Follow-up
- Activity restrictions—it is often helpful to discuss this in front of a family member
- Wound care—instructions should be given orally and provided in writing with instructions on who to call with problems or concerns

- Follow-up—appointments should be scheduled if needed and it is helpful to inform patients if more than one visit will be needed
- Healing—preparing patients for what may occur postoperatively can eliminate anxiety and minimize phone calls. Discussing swelling, bruising, scarring, and the potential for scar revision upfront will help patients know what to expect as their wound heals
- Pain management
 - Ice, elevation
 - Recommended analgesics (e.g., acetaminophen, NSAIDs, narcotics) with timing and dosage recommendations
 - Elements that may be included when preparing patients
- Name of the hospital where the procedure is to take place
- Name of the specific procedure for which consent is being given (now commonly including location)
- Name of the practitioner performing the procedure
- Statement that the procedure, anticipated benefits, risks and alternatives were explained to the patient or their representative
- Signature of the patient or their representative

If the patient is interested in closure by another surgeon (plastic surgeon, oculoplastic surgeon, or other), this is often revealed during this discussion. This plan is ideally addressed during a preoperative consultation so that such arrangements can be coordinated in advance of the surgery. Patients who have many questions or voice cosmetic concerns when they are scheduling their procedure are self-identifying as individuals who would benefit from an in-office preoperative consultation. Seeing such patients ahead of time to discuss questions and concerns in detail will streamline the actual surgery day and alleviate patient and provider concerns.

Preparing patients for the postoperative period can begin during the preoperative consultation and extend through the end of the surgery. Patients, often nervous about their procedure, may not hear all instructions, and can benefit from repetition before and after surgery. Having a friend or family member present to hear instructions is ideal. If the patient is relaxed, reviewing instructions can often occur in part during the surgical procedure as well.

If there will be a pathology result, inform patients when this will be available and how they will receive the result (telephone call, e-mail, postcard, at the follow-up visit). It may be helpful to ask patients if they are comfortable receiving results over the phone and whether or not you can leave a message. It is important to have consent to leave a detailed message on voicemail or with a family member prior to doing so.

INFORMED CONSENT

Obtaining informed consent is one of the most important steps in the preoperative period. It establishes realistic patient expectations and creates a protective legal framework for the physician to operate within. Failure to inform patients adequately of the potential associated risks and expectations can be viewed as negligence, and performing a procedure on a patient without their express consent can be considered battery in a court of law, although witnessed verbal consent may be acceptable in some situations. The patient must be provided the information to adequately evaluate a procedure before agreeing to that procedure or surgery. The Joint Commission defines informed consent as agreement or permission accompanied by full notice about the care, treatment, or service that is the subject of the consent.¹

Before consent can be obtained, the physician must determine whether or not the patient has decision-making capacity. The patient must be over the age of 18 and mentally able to grasp the concepts presented. It is necessary to obtain consent from the health care proxy or guardian of mentally incompetent patients. There are many other potential barriers to patient understanding, including ineffective provider communication; lack of patient-provider shared decision making; lack of health literacy; and cultural issues. The surgeon must be alert to signs of inadequate patient understanding. Simplification of the content, length, and language may help reduce these communication barriers. A qualified medical interpreter may be utilized for patients with hearing or visual impairments or limited English fluency, though other technology-based communication approaches may be used as well. Asking the patient to summarize the discussion and their decision can also help to highlight those who have failed to understand, and it is up to the physician to uncover the barrier to effective communication and correct it before the procedure is initiated.

Once the surgeon has established the patient's competence, they may move on to detail the critical components of informed consent. These include an explanation of the proposed procedure in lay terms, an explanation of the reasonable standard of care, indications for the procedure, common adverse outcomes, unexpected adverse effects, and treatment alternatives, including the expected consequences of no treatment.

Risks to be discussed should include those that either a reasonable physician would disclose or a reasonable patient would think necessary to make an intelligent decision. This means that extremely rare risks need not be discussed, though these standards leave much ambiguity. The surgeon should review the likelihood of those risks based on available clinical evidence and their judgment. Risks addressed should include common adverse events (which may be mild), as well as those that are unlikely but severe. The patient should have the opportunity to refuse the procedure if they deem any of those risks intolerable.

For cases in which residents or fellows in training are participating, the attending physician should explain who will be performing the procedure. Patients should be informed that physicians in training will be performing portions of the procedure commensurate with the ability of the resident or fellow, and will be under the supervision of the teaching physician. Whether or not the supervising physician will be present during all portions of the procedure should be explained, as this may vary based on the level of competence of the trainee.

While a written signature is required, the real goal of the consent process is effective communication. Inadequate communication was found to be the root cause of the majority of unmet expectations and/or complaints reported to the Joint Commission.¹ Technically, informed consent does not need to be written, but without written documentation, it is difficult to prove the patient's agreement in a court of law. It is generally agreed that a written consent form should be placed into the patient's medical record prior to the procedure. The one exception to this practice would be in an emergent life-threatening condition requiring immediate surgery, in which the principle of implied consent is invoked.

In 2007, the Centers for Medicare and Medicaid Services proposed updated guidelines for participating practitioners obtaining consent.² Under these guidelines, consent must be a written document in the patient's medical

record and must include additional details, such as the name of the surgeon and a reference to the risks, benefits, and alternatives.

CONCLUSIONS

Patient preparation and the informed consent process is a critical part of the surgical procedure. Without adequate preparation, even mild and expected outcomes, such as edema and ecchymoses, can be a cause for significant concern. Working as a team with the patient, and appreciating that the patient is indeed the most important person in the room, helps guide appropriate decision making. A full discussion of benefits and risks improves mutual trust and respect between the physician and patient, and ultimately improves patient satisfaction.

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CHAPTER 4 The Surgical Suite

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SUMMARY

- A well-equipped, well-designed surgical suite improves the surgical experience for the patient as well as the dermatologic surgeon and maximizes patient safety.

- Dermatologic surgeons have historically operated in an array of surgical settings, including hospital operating rooms, outpatient ambulatory surgical centers (ASCs), and office-based surgical suites.
- The surgical suite or operating room needs to be well lit, well ventilated, and include ample floor space for an electric operating table, emergency equipment, Mayo stand(s), instrument storage, electrosurgical equipment, and sink.

Beginner Pearls



- Multiple electrical outlets in the surgical suite are very helpful.
- The surgical table should ideally be located at the center of the room. While a wider table may be more comfortable for larger patients, a narrow table allows the dermatologic surgeon to access the surgical site more easily and maintain good ergonomic posture.

Expert Pearls



- Eyeglass-mounted LED lights provide direct illumination for the surgical field and are increasingly becoming the norm as long-lasting battery packs coupled with a decreased price point make these the illumination technique of choice for many surgeons.

- Interior design features such as outdoor photographs, spacious rooms, and architectural window features providing more sunlight have positive effects on perceived anxiety and postoperative pain.
- Aesthetically pleasing healing environments can have a positive influence on patients, and many authors recommend the purposeful use of architecture, art, and music to improve the surgical experience for the patient.
- Since surgical rooms are often kept at a cooler temperature than other offices (given the heat generated by lighting, surgical gowns, and other equipment), for patients' comfort, extra blankets and pillows may be made available.

Don't Forget!



- Ergonomic approaches to minimizing injury risk for the surgeon include modifying footwear, flooring, surgical instruments, operating position, lighting, and table height.
- When designing and building a dermatologic surgery suite, it is important to consider future growth.

Pitfalls and Cautions



- Erring on the side of larger operating rooms with abundant storage permits future expansion and flexibility.
- State and federal laws govern medical waste disposal.
- Multiple surveys of Mohs surgeons found that over 90% of respondents experienced symptoms exacerbated by surgery including stiffness and pain of the neck, shoulders, and lower back, as well as headaches.

CHAPTER 4 The Surgical Suite

INTRODUCTION

Dermatologic surgery encompasses a broad range of procedural complexity, from standard procedures such as biopsies, electrosurgery, sclerotherapy, soft-tissue augmentation, and toxin/filler injections to more aggressive surgical procedures such as skin cancer excisions, Mohs surgery, complex reconstruction, laser resurfacing, liposuction, and hair restoration.

It is important that the dermatologist practice with skill in a well-equipped, well-designed surgical suite that improves the surgical experience for the patient as well as the dermatologic surgeon, and—most importantly—maximizes patient safety. Dermatologic surgeons have historically operated in an array of surgical settings, including hospital operating rooms, outpatient ambulatory surgical centers (ASCs), and office-based surgical suites.^{1,2} Any office-based surgical facility should ideally be organized into separate rooms providing reception, laboratory, and the surgical suite.

The ASC tends to be a sophisticated extension of the dermatologic surgery practice in which the ASC is a separate defined entity within a larger medical office. Specific requirements for ASCs vary from state to state, and therefore will not be addressed in detail. In general, facility fee reimbursement from third-party payers requires state licensure and Medicare certification.¹

The dermatologic surgeon needs a large dedicated room to operate comfortably, whether standing or sitting, along a 360-degree circumference around the patient.² The surgical suite or operating room needs to be well lit, well ventilated, and include ample floor space for an electric operating table, emergency equipment, Mayo stand(s), instrument storage, electrosurgical equipment, and sink. It should convey a comfortable, yet

efficient, professional appearance and be easily and frequently cleaned. Ideally, it should convey an atmosphere that reflects a clean, meticulous, well-organized, high-quality medical facility.³ In the event of an emergency, the surgical suite should be able to accommodate emergency equipment and personnel. Table 4-1 shows a “shopping list” of items needed for a typical surgical suite.

Table 4-1. The Surgical Suite Shopping List

Necessary	Ideal
Surgical table	Pulse oximeter
Light source (overhead or portable LED)	Full crash cart with oxygen
Electrosurgery device	Smoke evacuator
Stool	Suction
Sharps and biohazard waste disposal	Full surgical scrub sink outside of OR
Mayo stand	
Waterless hand cleanser	

Design

While each dermatologist may have their own opinion regarding what is needed in their operating room, statutory requirements should be considered first before designing their suite. The American Academy of Dermatology has published guidelines of care for office-based surgical facilities that can be utilized as a starting point for surgical suite design.^{4,5} Table 4-2 shows sizing suggestions for rooms, doors, and ceilings in the surgical suite.

Table 4-2. Sizing Suggestions for Rooms, Doors, and Ceilings

Component	Sizes and Specifications
Procedure room	12' × 12' minimum ideally
Hallways	5' minimum
Doorways	32"–51"
Ceiling height	7' 10" minimum; 9' is ideal
Waiting room	Consider separate procedural/Mohs waiting room
Flooring	Smooth and monolithic is ideal

The surgical table should be located at the center of the room. There should be approximately 3 ft of clearance room at the ends of the table and, ideally, 4 ft at the sides to allow easy access to the patient by the dermatologic surgeon, surgical assistant, and circulating staff. A power outlet should ideally be wired into the center of the floor to eliminate power cords running across the floor to a wall socket.

Multiple electrical outlets in the surgical suite are essential, especially if a room is utilized for multiple procedures such as reconstruction, electrosurgery, and light-based procedures. When designing a surgical suite from the ground up, wiring all surgical rooms for 220 V would be wise in the event that lasers or other special equipment are added in the future.¹ Room access may be via a pocket door, rather than a swinging door, to permit the room to be separated from the rest of the office environment while maximizing floor space (Fig. 4-1).²

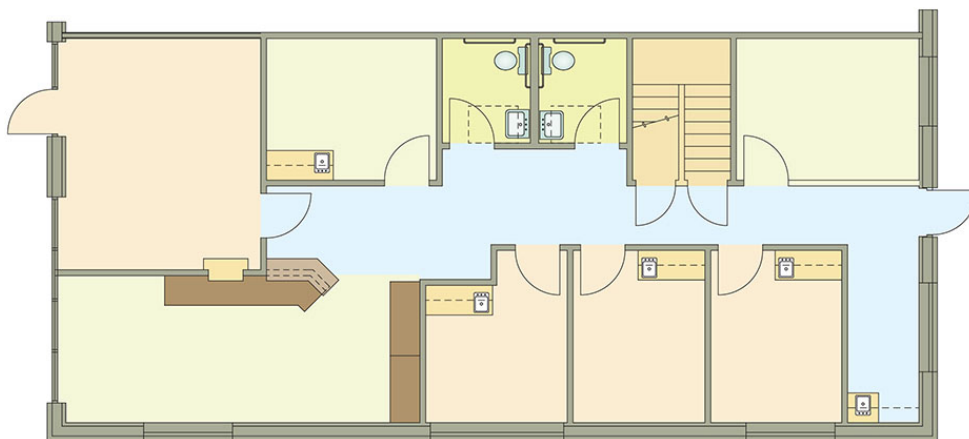


Figure 4-1. Representative surgical suite blueprint.

Temperature

The surgical suite should maintain a comfortable ambient temperature with relatively low humidity; generally, surgical rooms are kept at a cooler temperature than other offices, given the heat generated by lighting, surgical gowns, and other equipment. For the patients' comfort, extra blankets and pillows may be made available. Body warmers may be used for recovery, though these are generally not utilized in the outpatient setting. During long procedures, patients may benefit from a pillow behind their knees to reduce perceived back pressure.

Lighting

Proper lighting and visualization of the surgical field is of paramount importance when performing surgical procedures. Natural light in the surgical suite through sealed windows is encouraged. The room should have good general lighting with standard fluorescent or LED lights that illuminate the central working area. General room lighting may be augmented by a large, adjustable, ceiling-mounted overhead operating room light. Shadowless lighting delivering precision illumination is the ideal, and there are many options available.² Lights should be adjustable during surgery, which may be accomplished by using sterile disposable handle covers, sterilized aluminum foil, or autoclavable handles that can be screwed in place. Alternatively, eyeglass-mounted LED lights provide direct illumination for the surgical field and are increasingly becoming the norm as long-lasting battery packs coupled with a decreased price point make these the illumination technique of choice for many surgeons (Fig. 4-2).



Figure 4-2. Overhead-mounted operating room lights.

Sinks

The sink should be at a height that facilitates comfortable hand and arm washing. Some authors maintain that a surgical sink with foot pedals is preferable for the surgical suite.⁶ While more expensive than conventional sinks, they prevent contamination of the hands when turning off the faucet controls. They may be paired with foot-operated soap dispensers. Hands-free electronic sensors may also be used for sink activation. A sink depth of 18 to 24 in may be helpful to decrease splash and encourage a good water stream when hand washing (Fig. 4-3).⁷



Figure 4-3. Standard room stainless-steel sink.

Ergonomics

Though dermatologic surgeons rarely complain about physical stress or discomfort, they should be aware of some of the hazards of work-related injuries and how to avoid them. An appreciation of ergonomics, the study of fitting the job to the worker and altering the work environment and tasks to the capability of the one performing work, is very helpful when designing a surgical suite.^{8,9}

A 2007 survey of Mohs surgeons found that 94% of survey respondents experienced symptoms exacerbated by surgery including stiffness and pain of the neck, shoulders, and lower back, as well as headaches.¹⁰ Analysis of these surgeons found that ergonomic issues existed with operating room setup, awkward posture, poor positioning, length of procedures, and lighting. A similar survey of Mohs surgeons, conducted in 2010, found that 90% of respondents experienced musculoskeletal symptoms or injuries.¹¹ Again, the neck, shoulders, lower and upper back were the most commonly affected areas. These injuries were attributed to lack of ergonomic modifications

within the surgeons' practice, and were seen to start early in their career, at an average age of 35. Recommendations from these studies included modifying footwear, flooring, surgical instruments, operating position, lighting, and table height. Other surgical subspecialties, such as otorhinolaryngology and gynecology, report a similar incidence of musculoskeletal pain. A common theme among specialties is a lack of awareness and/or implementation of ergonomic principles.

Ergonomic professionals and resources, such as the OSHA website on Healthcare Wide Hazards (<https://www.osha.gov/SLTC/etools/hospital/hazards/ergo/ergo.html>) can be employed to optimize ergonomic interventions. Attention to these practices can improve day-to-day comfort and potentially career longevity.

Aesthetic considerations

Aesthetically pleasing healing environments can have a positive influence on patients, and many authors recommend the purposeful use of architecture, art, and music to improve the surgical experience for the patient.^{12–14} A 2013 study on patient anxiety while undergoing Mohs surgery found that the presence of music correlated with decreased anxiety and pain.¹⁵

A systemic review of the effectiveness of art, music, or appealing interior design was performed, and 48 studies were examined.¹⁶ The meta-analysis concluded that these low-cost interventions help alleviate postoperative pain, anxiety, and even resulted in decreased blood pressure and heart rate compared to control groups. Simple adjustments to the surgical suite, such as introducing a calming environment with music or pleasing interior design can be beneficial in reducing patient qualms over surgical procedures. Self-selection of the music by the surgical patient is an effective and low-cost intervention to minimize anxiety and enhance well-being. Newer technologies permit easy access to music whether using a CD player, radio, as well as free or low-cost computer-based applications such as Pandora or Spotify. Moreover, interior design features such as outdoor photographs, spacious rooms, and architectural window features providing more sunlight were found to have positive effects on perceived anxiety and postoperative pain (Figs. 4-4 and 4-5).



Figure 4-4. In-room artwork may induce a calming environment.



Figure 4-5. Spacious architecture and natural sunlight from sealed windows may improve the surgical experience.

EQUIPMENT

Emergency equipment

Surgery limited to the skin and subcutaneous tissue, when performed under local anesthesia, does not require the need for emergency equipment and continues to be exempted by most state regulations. It remains the responsibility of the physician to ensure that the surgical facility is in compliance with local and state government regulatory bodies.

More advanced surgical suites should be equipped with an emergency crash cart in case of cardiopulmonary arrest or life-threatening drug reaction. Key office staff should be trained in basic CPR and ACLS. In addition, an emergency plan for patient transfer to a hospital should be in place.

As a general guideline, an emergency crash cart should include the following: automated external defibrillator (AED), oropharyngeal airway, laryngoscope with endotracheal tubes of various sizes, positive-pressure ventilation device with airways of various types and sizes, oxygen tank with

delivery system, IV catheters of various sizes, bags of intravenous fluids, prefilled syringes/ampules including epinephrine, atropine, dextrose, lidocaine, sodium bicarbonate, hydrocortisone, naloxone, flumazenil, diphenhydramine, and furosemide (Table 4-3).

Table 4-3. Crash Cart Contents (Based on AHA Guidelines)

Equipment	Drugs
Airway (oral and nasal) all sizes	Aspirin 81-mg tablets
McGill forceps, large and small	Nitroglycerin Spray or 0.4-mg tablets
King Airway Set (3) Eliminates the need for Laryngoscope and Endotracheal tubes	Dextrose 50% (Dextrose 25% if treating pediatrics)
Bag Valve Mask (Adult and Pediatric)	Narcan 1 mg/mL (6)
Nasal Cannula	Epinephrine 1:10,000 Abboject (3)
Non Rebreather Oxygen Face Masks (3 sizes)	Atropine Sulfate 1 mg Abboject (3)
IV Start Packs	Amiodarone 150 mg vial (4)
Normal Saline Solution (1000-mL bags)	Epi Pen (2)
IV Tubing	Epi Pen Jr (2)
Angiocaths (various sizes)	Solumedrol 125 mg vial
10-mL Normal Saline Flush Syringes (3)	Benadryl 50 mg vial (2)
Gauze	Adenosine 6 mg (4)
Alcohol Preps	Lopressor 10 mg (2)
Monitor with Defibrillator or AED	Cardizem 20 mg vial (2)
Syringe nasal adaptor (nasal narcan atomizer)	Pronestyl (Procainamide) 1 g in 10 mL 100 mg/mL vial (1)

Other emergency items recommended for the surgical suite include blood pressure/pulse monitoring, a pulse oximeter, a suction device, fire extinguisher, and eyewash station.

The surgical table

The surgical table is the centerpiece of the operating room and one of the dermatologic surgeon's most important equipment purchasing decisions. The surgical table should be electrically foot operated, easily adjustable, well padded, and comfortable. Variables to consider include table width and entry height. While a wider table may be more comfortable for larger patients, a narrow table allows the dermatologic surgeon to access the surgical site more easily and maintain good ergonomic posture. Surgical tables with a low entry height are very important for the elderly or disabled, and facilitate easy transfer from wheelchairs. Other accessories to consider include armrests, headrests, armboards, footboards, and stirrups. Patients feel less anxious and more secure if they can easily rest their arms and shoulders without fear of rolling off the table.

Adjustability is another consideration when choosing a surgical table. The importance of maintaining flexibility in patient positioning cannot be exaggerated. The tilt adjustment should allow the table to place the patient in the Trendelenburg position, helpful when managing vasovagal reactions. A useful tip for automated tables is to utilize the Trendelenburg position as a preset, so that it can be accessed rapidly.

With the increasing prevalence of obesity worldwide, newer facilities often consider measures for obese patients when choosing their surgical table and designing their surgical facility. However, despite the newest equipment, access to the surgical site in these patients remains challenging.

Surgical stools

The dermatologic surgeon should be able to stand or sit when necessary. A comfortable, sturdy, foot adjustable, rolling surgical chair should be located on each side of the surgical table. There are a variety of surgical stool designs available, including those with back support and arm rests.

Electrosurgery and hemostasis

An electrosurgical device for hemostasis is essential in dermatologic surgery.¹⁷ In electrosurgery, high-frequency, alternating electric current is passed through the skin to generate heat. It requires a power supply and a handpiece for the electrode. A sterile dedicated electrode tip should be used for each patient. Electrosurgery includes electrofulguration, electrodesiccation, electrocoagulation, electrosection, and thermocautery. Electrosurgery may be monoterminal, monopolar, or bipolar. A wide variety of devices are available for electrosurgical hemostasis. For a full discussion of electrosurgery and hemostasis, see [Chapter 16](#).

The use of a smoke evacuator should be considered for several reasons. The smell of burning skin can be disconcerting to patients, and the plume may lead to respiratory irritation in patients and staff. In addition, while there is no documented transmission of infectious diseases through surgical smoke, there is a theoretical potential for viral particle transmission.^{18,19}

Mayo stands

Mayo stands are an essential part of the surgical suite, allowing moveable easy access to surgical instruments during procedures. Some surgeons prefer two Mayo stands to place surgical instruments on one and wound dressing materials on the other.² The options to consider when selecting a Mayo stand include size, movement, mechanism for lifting and lowering the platform, the base of the stand and possible presence of a circular base for kick-bucket placement, and the rolling mechanism.

Safety and waste containers

Dermatologic surgery exposes surgeons and assistants to potentially dangerous blood-borne pathogens. All surgical suites or operating facilities should be equipped with personal protective equipment such as masks, eye protection, and gloves.

State and federal laws govern medical waste disposal. It is important to review relevant information from regulatory agencies to ensure that the surgical suite meets local, state, and federal standards. The surgical suite needs to be equipped with proper waste disposal devices for all sharps and biohazardous materials. Kick buckets, stainless steel waste receptacles on wheels, are easily moved for ready access and disposal of waste and should be emptied between each procedure.^{1,2}

There are three recommended types of waste disposal (Table 4-4).

Table 4-4. Waste Disposal Options

Waste Type	Disposal Method	Relative Cost
Sharps	Container should be durable, closable, and puncture and leak resistant	\$\$
Contaminated waste; soaked with blood	Placed in a biohazard container or red bag	\$\$\$
Non-blood-soaked waste	Dispose of in standard fashion as with normal waste	\$

1. Sharps disposal container should be durable, closable, and puncture and leak resistant.
2. Contaminated waste should be placed in a biohazard container or “red bag.” The method of disposal may require expensive services for elimination of this by-product.

3. Noncontaminated waste, that is, paper drapes, paper towels should be disposed of like normal waste.

CONCLUSIONS

When designing and building a dermatologic surgery suite, it is important to consider future growth. Erring on the side of larger operating rooms with abundant storage permits future expansion and flexibility. Consultation with colleagues, architects, contractors, interior designers, and occupational health specialists is recommended. Most importantly, designing and building the surgical suite takes a significant amount of time, effort, and planning, and should represent a source of both pride for the surgeon and comfort and safety for the patient.

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CHAPTER 5 Surgical Instrument Selection

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SUMMARY

- Surgical instrument choice may have a direct impact on outcomes, and certainly leads to less traumatic and faster procedures.
- Investing in high-quality instruments is generally a wise decision.
- The highest-quality instruments are the longest lasting, provide the best surgical outcomes, and allow for optimal comfort and speed. Using inadequate instrumentation may lead to need for frequent replacement, poor performance, and tissue damage.
- While the majority of procedures may be completed with a few basic instruments, there is a wide array of available instruments that may be used for specialty procedures.

Beginner Pearls



- Consider purchasing instruments at conferences in order to both sample the range of choices and save on costs.
- Surgical packs do not require an exhaustive array of instruments.
- When training staff, including a laminated photograph of the surgical pack above the area where instruments are washed and packaged is a helpful training tool.

Expert Pearls



- Consider color-coding instrument packs for ease of organization and consistency.
- Maintain basic surgical packs and add specialized instrumentation as needed. Instruments used in less than 25% of cases may be kept in separate packs as long as they are easily accessible.
- When using larger suture needles, such as those on 2-0 suture, be sure to use larger and heavier needle drivers, as fine needle drivers may be loosened by clamping on more robust needles.
- Supercut scissors are denoted by black handles. The upper blades of these scissors are honed with a double, rather than single, bevel, similar to the blade of a high-quality knife or scalpel and the lower jaw is serrated. These scissors optimize tissue cutting in most circumstances, but the sharp blade is easily dulled.
- Some surgeons use a skin hook in place of forceps for skin reflection during suturing to minimize the risk of tissue strangulation.

Don't Forget!



- Beware the temptation to create overly comprehensive surgical packs. Many accomplished dermatologic surgeons work with a basic set of high-quality instruments.
- Suture-tying platforms are extremely helpful; it is always preferable to use toothed forceps with platforms rather than nontoothed forceps, as the latter increase the risk of tissue strangulation.

Pitfalls and Cautions



- Always autoclave instruments in the open position to avoid buckling.
- Avoid using supercut scissors to cut anything but tissue.
- Staff should always be responsible for their own sharps disposal, which should be performed before the used instruments are removed from the room.
- The jaws of a needle driver may be smooth or have fine teeth or ridges. Small teeth may assist in gripping the needle, but may also damage the suture material during handling and tying.
- The most common risk to both surgeon and assistant in dermatologic surgery is needle puncture, though the risk of disease transmission is low when using closed-bore sewing needles.

CHAPTER 5 Surgical Instrument Selection

INTRODUCTION

Optimal outcomes in dermatologic surgery require selection of the most appropriate surgical instruments. While the majority of procedures may be completed with a few basic instruments, there is a wide array of available instrument quality and selection.

Modern instruments are made from various metals or alloys, including stainless steel, chromium nickel, and tungsten carbide. Though numerous manufacturers are available, most readily available precision instruments are manufactured by several companies in Germany. In general, the highest-quality instruments are the longest lasting, provide the best surgical outcomes, and allow for optimal comfort and speed. Using inadequate instrumentation may lead to the need for frequent replacement, poor performance, and tissue damage.

In general, instruments used in dermatologic surgery are small, fine, and lightweight, allowing for proper atraumatic handling of delicate tissue and minimal operator fatigue. However, the thickness and quality of skin encountered in dermatology vary greatly, and specific instruments are designed for each of these skin types. A detailed description of instrument types and patterns, and their eponymous names, could fill a surgical equipment catalog. This chapter is intended as a guide to the general categories of instruments available, with emphasis on those instruments most commonly encountered.

Biopsy instruments

Small samples of skin are frequently needed prior to performing comprehensive dermatologic surgery procedures. While standard dermatologic surgery instruments such as scalpels may be used, specialty instruments have been developed to simplify biopsy procedures.

Punch biopsy instruments, or punches, are designed with a cylindrical cutting blade attached to a handle (Figs. 5-1 and 5-2). Though reusable devices were originally used, most have been replaced by disposables. These disposable punches provide both sterility and a razor sharp edge. Useful punches range from 2 to 8 mm in diameter. An elliptically shaped punch has also been developed to facilitate elegant closure. However, many surgeons find this device to be difficult to use, as the punch cannot be rotated to enhance cutting.

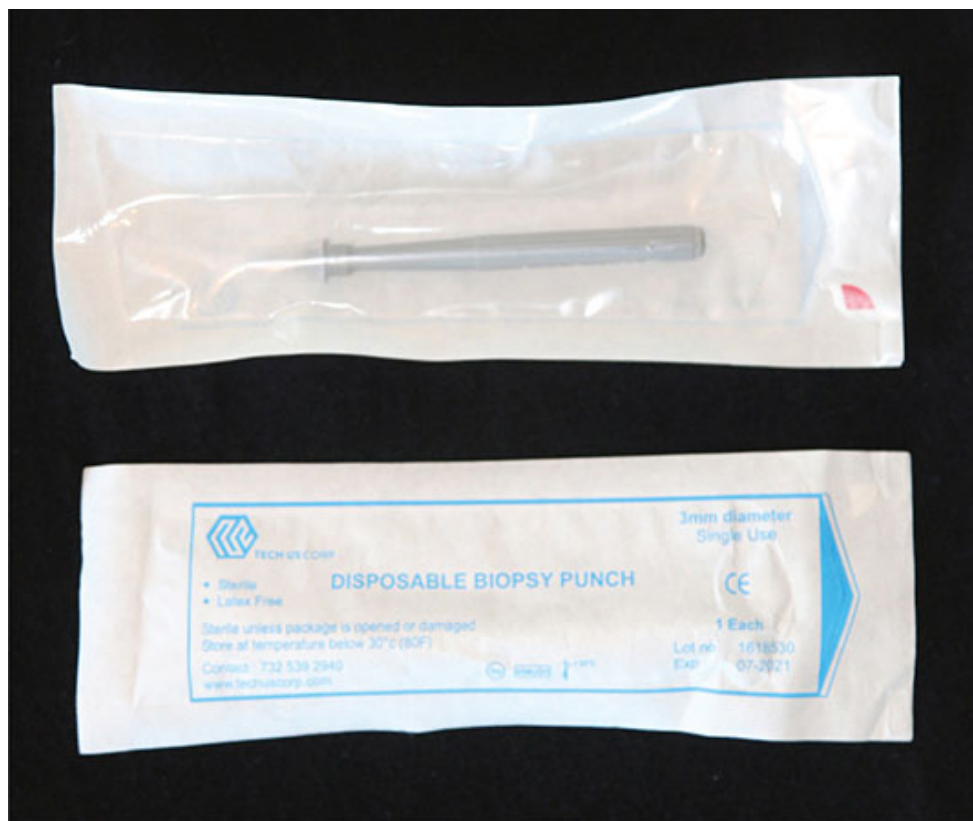


Figure 5-1. Punch biopsy instruments are available in an array of sizes and configurations.

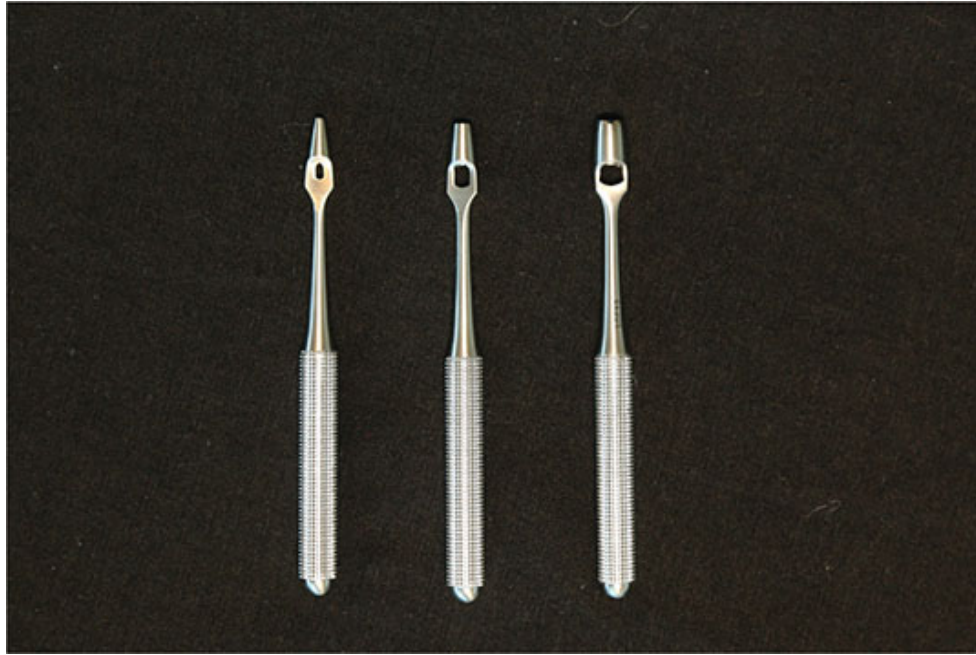


Figure 5-2. Some punch devices are autoclavable.

A shave biopsy may be performed with any sharp-edged cutting instrument. A double-edged razor blade, snapped in half, provides an extremely sharp and inexpensive tool for shave biopsy. By altering the curvature of the blade between their fingers, the surgeon may adjust the depth of the biopsy. Scalpel blades are also readily available, and may be stabilized by wrapping the base of the blade in its foil packaging. The Dermablade is a commercially available blade with plastic support handles. This may provide improved grip and safety to the surgeon as compared to working with a snapped double-edged blade, though it is significantly more expensive and most veteran dermatologic surgeons are expert at handling snapped double blades.

Curettes

The curette is a surgical instrument designed for scraping ([Figs. 5-3](#) and [5-4](#)). The handle may be of various weights, lengths, and textures. The head, usually crafted from the same piece of metal as the handle, may be round or oval, cup or ring shaped, ranging from 1 to 10 mm wide, and is sharp on one side. Curettes are most commonly used to remove or destroy benign or malignant lesions. They may also be used to debulk and delineate tumor

margins prior to excision or Mohs surgery. As with other surgical instruments, the most appropriately sized instrument for the procedure should be selected to facilitate destruction while avoiding surrounding tissue damage.



Figure 5-3. Curettes are available in various weights, lengths, and textures.



Figure 5-4. Larger curettes may be used for thicker tumors.

Curettes are available in both disposable and reusable designs. Disposable curettes have a sharper tip, and function similarly to a curved scalpel blade. Most surgeons favor the reusable instruments, as their blunter edge provides improved sensory feedback, allowing the surgeon to better differentiate between various tissue types.

Scalpels

Scalpels may be used for cutting, puncturing, dissecting, manipulating specimens, and scraping. They generally consist of a handle and a blade. Both the handle and blade are available in numerous sizes and materials. Selection is based upon both surgeon preference and the surgical application.

Scalpel blades are disposable, individually wrapped, and pre-sterilized. They may be made of carbon steel or stainless steel. Carbon steel blades are sharper, though they dull more rapidly. Stainless steel blades are not as sharp but last longer. Blades may be coated in silicon or polytetrafluoroethylene to minimize tissue drag and increase longevity. These may be particularly useful in longer procedures or multi-staged Mohs surgical procedures.

The most common surgical blades in dermatologic surgery are the 15, 15c, 10, and 11 blades. These blades are designed to fit a variety of available handles. The 15 blade's small size and gentle curvature make it optimal for the majority of skin procedures. The sharp tip is used to initiate cuts, while the broader belly provides a longer surface for enhanced contact. With the handle held at 30 degrees to the skin, longer smooth cuts may be made. The 15c blade is a smaller variant, used to treat very delicate skin; its sharper carbon blade also dulls faster. The 10 blade also shares a similar shape but is significantly larger, making it optimal for thicker skinned areas such as the back. The 11 blade is triangular with a straight edge that tapers to a sharp point. It is usually used in a stabbing motion for incision and drainage.

Each of the above blades may be fitted interchangeably on a variety of handles (Fig. 5-5). The flat number 3 handle is most frequently encountered. It is well suited to the majority of procedures and is available with an imprinted metric ruler. The cylindrical Siegel handle has a gnarled grip and is useful for smooth, curved motions, such as removing round, beveled Mohs surgery specimens.



Figure 5-5. Surgical blades may be fitted interchangeably on a variety of handles.

An alternative handle and blade combination is the miniblade or Beaver system. In this system, smaller blades are inserted into a collet, which is tightened with rotation. Blades are available in a variety of shapes and curvatures. This system may be used in smaller, narrow spaces such as the ear canal or medial canthus.

Scissors

Surgical scissors come in a great variety of shapes and sizes, each designed for a specific task. Though the choices are dizzyingly extensive, the selection of a few optimal pairs of scissors may enhance comfort and surgical outcomes.

The basic anatomy of scissors consists of three parts: the handle, the blade, and the tip. The handle may be long or short. Short-handle scissors are most commonly used by dermatologic surgeons, as they provide enhanced control when working with delicate tissue. Longer handles provide increased leverage and cutting strength and may be necessary when working in cavities, such as when creating a flap for a facelift, or during extensive undermining. Handles are most often straight, though curved or bent handles are available. These alternative shapes may improve visibility or approach for difficult-to-reach areas.

Scissor blades are available in varying shapes and quality. In the most basic design, the blade is formed from the same piece of stainless steel as the handle. Such scissors are inexpensive and well suited for basic procedures, for cutting sutures, and for forming bandages.

The lower blade of a scissor may be serrated to increase stability and reduce slippage. These fine teeth are difficult to visualize, but may be easily felt by running the finger gently along the blade. The serrated blade is particularly useful when working with thin skin and for trimming the edges of delicate flaps and grafts. Scissors may be purchased serrated, or this feature may be added after manufacture.

Higher-quality scissors may be enhanced with tungsten carbide inserts. This material reinforces the blade, improving cutting and providing a longer life without dulling. Tungsten carbide is brittle, and may be damaged if instruments are dropped or mishandled, though the insert may be replaced.

when dulled or damaged. Surgical instruments with tungsten carbide inserts are identified by their gold handles.

Supercut scissors are denoted by black handles. The upper blades of these scissors are honed with a double, rather than single, bevel, similar to the blade of a high-quality knife or scalpel. The lower jaw is serrated. These scissors optimize cutting in most circumstances. The sharp blade, however, is easily dulled. Supercut scissor should be reserved for tissue and should never be used to cut suture.

Scissor tips may be pointed, blunt, or hooked. Pointed tips are useful for precise trimming and shaping and for aggressive dissection in areas of difficult scissor insertion. Blunt tips are safer for undermining around delicate structures and for freeing flaps and grafts. The single-hooked tip may be used to assist with suture removal.

By altering handle, blade, and tip shapes and sizes, many hundreds of scissor designs have been introduced. While a detailed description of each is beyond the scope of this chapter, several common types comprise the majority of our armamentarium.

Iris scissors are the most commonly used scissor in dermatologic surgery (Fig. 5-6). Originally developed for the eyelid, these have wide application for facial and other cutaneous surgery. These usually measure approximately 4 inches, may have straight or curved blades, and may have sharp or blunt tips. Their relatively long handle-to-blade ratio provides excellent accuracy while retaining mechanical advantage. The blepharoplasty scissor is a specialized iris scissor with a gentle curve, blunt tips, tungsten carbide inserts, one serrated blade, and one flattened blade. In addition to its original intention, this scissor may be particularly useful for dissecting cysts, and for debeveling and undermining wounds prior to closure.



Figure 5-6. Numerous scissors are available for use in dermatologic surgery.

Gradle and tenotomy scissors have a high handle-to-blade ratio and a small, delicate, sharp tip that is tapered to a fine point with a gentle curve (Fig. 5-7). Their fine features and precision make them ideal for working with delicate tissues or for harvesting thin stages during Mohs surgery.



Figure 5-7. Gradle scissors have a high handle-to-blade ratio and a small, delicate, sharp tip that is tapered to a fine point with a gentle curve.

Operating scissors are larger, heavier instruments more commonly used in general surgery. While these have limited use in dermatologic surgery, some may be helpful in larger cases. Mayo scissors are heavy, with a nearly one-to-one handle-to-blade ratio. These may be used for coarse dissection.

Metzenbaum scissors are heavier, with a high handle-to-blade ratio for increased leverage and reach.

At the more delicate end of the spectrum are Westcott and Castroviejo scissors (Fig. 5-8). These spring-loaded instruments are held like a pencil and squeezed closed to cut. The blade reopens when released. They generally have fine, pointed tips, and are particularly useful when working with thin periorbital skin.

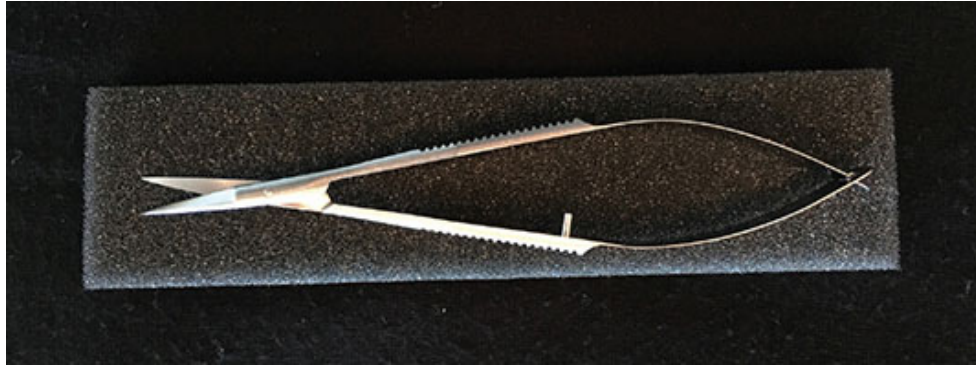


Figure 5-8. Castroviejo scissors are spring-loaded and held like a pencil.

The scissors discussed above are intended for tissue and may be damaged when working with other materials. A surgical tray should also contain scissors for cutting suture. Suture-cutting scissors may include a basic stainless steel iris scissor or a standard operating scissor, which comprised of heavier blades with one blunt and one sharp tip. Bandage-cutting scissors tend to be large and have blunt tips to protect the patient's skin during the removal of the bandage (Fig. 5-9). One blade is generally flattened to slide under the dressing without damaging the underlying integument. For suture removal, the Northbent scissor is curved with a hooked blade, the Spencer scissor is straight with a hooked blade, while the O'Brien scissor has a short-angled blade that allows the fine tip to be introduced below suture loops (Fig. 5-10).



Figure 5-9. Bandage-cutting scissors tend to be large and have blunt tips to protect the patient's skin during removal of the bandage.



Figure 5-10. For suture removal, the Northbent scissor is curved with a hooked blade.

Forceps

Forceps are used to hold or grasp items such as tissue, sutures, or other materials within the surgical field. They are generally held between the thumb and index finger like a pencil. They are pressed to close, and are designed to reopen with released. As with other surgical instruments, forceps are available in a variety of sizes and weights. While a matter of personal preference, the most delicate instrument useable for the procedure should usually be selected to avoid tissue damage.

Forceps handles are usually stainless steel. They are available in a variety of weight and lengths. Grips may be ridged or gnarled for improved grip when wet. Handles may also be drilled or fenestrated for weight reduction.

Surgical forceps are available with or without teeth. Those without teeth are referred to as dressing or bandage forceps, and are for the most part, not intended to handle the skin. Tissue forceps, on the other hand, have delicate teeth at the tips. When used gently, these tips allow the skin to be manipulated without crushing or leaving marks on the skin. Teeth are available in various weights and sizes to correctly suit the tissue. The most commonly used tooth pattern is 1×2 , meaning one tooth on one tip that fits between two teeth on the other tip. However, multiple tooth patterns such as 2×3 through 8×9 are available.

Some forceps are available with a suturing or tying platform ([Fig. 5-11](#)). This is a slightly raised, flattened area placed directly behind the teeth. This platform allows the needle to be gripped securely without twisting or turning. The needle can, therefore, be passed directly from the needle driver to the forceps without touching the needle with the fingers. This may greatly reduce the risk of needle stick to the surgeon. For optimal grip and ease of maintenance, this platform may be constructed of gnarled tungsten carbide. Such forceps are denoted, like all tungsten carbide instruments, with gold handles.

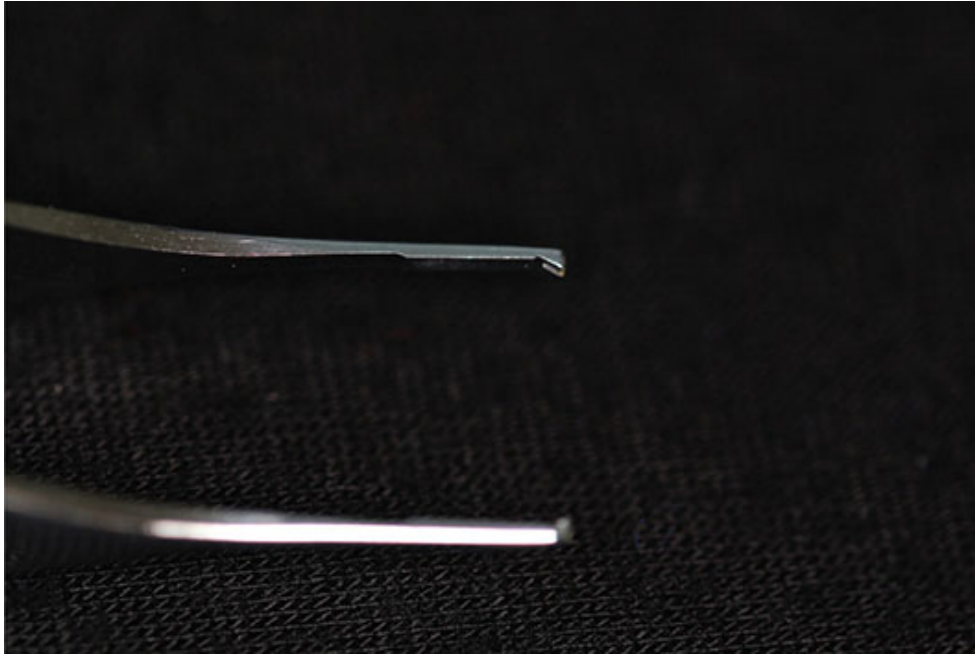


Figure 5-11. Some forceps are available with a suturing or tying platform.

The most common forceps design used in dermatology is the Adson (Fig. 5-12). These have a broad handle that tapers to a narrow tip. This tip may be serrated, smooth, or toothed; Adson forceps are available with or without tying platforms. Long, heavy handles or lightweight, fenestrated handles are available. By varying these characteristics, Adson forceps suited for nearly all dermatologic surgery procedures have been produced. A common variation is the Brown–Adson forceps, in which a platform of minute teeth is placed at the tip.



Figure 5-12. The most common forceps design used in dermatology is the Adson.

For more delicate procedures, small forceps with a longer tip-to-handle ratio are available. Iris forceps are simple, inexpensive, and slowly taper from handle to tip. Bishop–Harmon forceps are short, with fenestrated handles and well-defined, long, delicate tips. These are available with or without teeth. Jeweler’s forceps are similarly delicate, with tapered sharply pointed tips.

Nontissue handling forceps are also commonly used in dermatologic surgery. Those with smooth tips may be useful for gripping sutures or foreign bodies. The Swiss cilia forceps is short, with a smooth, angled, pointed tip (Fig. 5-13). This is particularly useful in suture removal. Forceps with serrated tips increase the gripping strength and may be used to manipulate gauze within a surgical field. While they may also be used to grasp cysts or lipomas, their use on vital tissue may lead to tissue damage or necrosis.



Figure 5-13. The Swiss cilia forceps is short, with a smooth, angled, pointed tip.

Needle drivers

Needle drivers, or holders, are clamped instruments intended to hold a surgical needle securely when suturing. When closed, a ratchet activates to grip the needle without effort. To release the clamp, the handles are separated laterally. Designed similarly to scissors, these are available in varied weights, handle lengths, tip shapes, and tip materials. While designs vary, the smallest instrument that can be comfortably used to execute the task is recommended. Further, smaller needle drivers are optimized to hold smaller needles, and may be damaged by larger needles, while larger drivers are intended to hold larger needles, and may bend smaller ones.

The jaws of a needle driver may be smooth or have fine teeth or ridges. Small teeth may assist in gripping the needle, but may also damage the suture material during handling and tying. Horizontal ridges may be found in other needle driver jaws. These are intended to keep the surgical needle from twisting. However, fine sutures may pass through these ridges when gripping the suture to perform an instrument tie. Rough-surfaced tungsten carbide inserts are available to improve instrument durability and increase needle

grip. These are also replaceable. As usual, these instruments are denoted by gold handles, and are more expensive than other options.

The eponymous Webster, Halsey, Baumgartner, Crile–Wood, and Mayo drivers are most commonly used in dermatologic surgery (Fig. 5-14). These are similarly shaped, with long handles and short tips. They are available in various weights and lengths to optimize needle handling and physician comfort. Most are available with each of the above-discussed tip types.



Figure 5-14. A variety of needle drivers are available for dermatologic surgery.

For more delicate procedures, particularly on eyelids, Castroviejo needle holders may be used. Similar to the Castroviejo scissor, these are delicate spring-loaded instruments. Unlike most needle drivers, these are available in both locking and nonlocking variants.

The Olsen–Hegar needle holder contains a scissor just proximal to the needle holding jaws (**Fig. 5-15**). These are often favored by a surgeon working without assistance. It may be used to suture and cut suture without changing instruments. However, care must be taken to avoid cutting the suture material accidentally while working.



Figure 5-15. The Olsen–Hegar needle holder contains a scissor just proximal to the needle holding jaws.

Hemostats

Hemostats are grasping devices, similar to forceps, but with a ratcheted locking mechanism like a needle driver (**Fig. 5-16**). These are used to temporarily clamp bleeding vessels during surgery; vessels can later be

sealed with electrosurgery or ligated with sutures before the hemostat is removed. Like needle drivers and forceps, hemostats may vary in length, tip size, curvature, and degree of serration. Common variants include the Jacobsen, Halsted, and Hartman. Small, lightweight hemostats, colloquially referred to as “mosquitos,” are most often used in dermatologic surgery.



Figure 5-16. Hemostats are grasping devices, similar to forceps, but with a ratcheted locking mechanism like a needle driver.

Skin hooks

The skin hooks used in dermatologic surgery are long, tapered instruments with a small, sharp hook at the end ([Fig. 5-17](#)). These are used to delicately manipulate tissue to improve field visualization, assess flap movement, or reflect skin edges during undermining or electrosurgery. Some surgeons use a skin hook in place of forceps for skin reflection during suturing. The chief disadvantage of the skin hook is the sharp tip and resultant risk of puncture injury to the surgeon or assistant.



Figure 5-17. Skin hooks used in dermatologic surgery are long, tapered instruments with a small, sharp hook at the end.

Skin hooks are available in single-, double-, or multi-pronged patterns, with the latter being described as rakes. Larger, wider instruments may be useful when manipulating heavy truncal skin, while delicate single-tipped hooks are most useful on the face.

Miscellaneous instruments

The chalazion clamp consists of a flat arm opposed by a ring. As these are clamped down on a mobile, vascular surface such as the lip, eyelid, or earlobe, the ringed arm provides stabilization and hemostasis, while the flat arm provides a backing surface against which the tissue can be cut. The clamp tension is adjusted by a thumbscrew, which can be gradually tightened or released. It is important to release the clamp as soon as possible to avoid tourniquet necrosis. Chalazion clamps are available in a variety of shapes and sizes. Rubber-coated clamps are recommended if electrosurgical instruments are to be used. Double-action nail cutters are also useful in nail

procedures, and can be used in place of rongeurs when working with superficial bone (Fig. 5-18).



Figure 5-18. Double-action nail cutters are also useful in nail procedures, and can be used in place of rongeurs when working with superficial bone.

Periosteal elevators are elongated flat instruments designed to lift the periosteum from the bone (Fig. 5-19). In dermatologic surgery, they are also frequently used to lift the nail plate off the nail bed. Bone chisels have a sharpened, flattened head and a broad handle. These may be struck with a small hammer to biopsy bone, usually if invasive neoplasm is suspected during Mohs surgery.



Figure 5-19. Periosteal elevators are elongated flat instruments designed to lift the periosteum from the bone.

Towel clamps allow sterile drapes to be firmly anchored in place (Fig. 5-20). They may also be used to keep electrosurgery handles within the operating field. Some surgeons additionally use the towel clip to hold large wounds together prior to suturing, or to grip a cyst or lipoma during extirpation.



Figure 5-20. Towel clamps allow sterile drapes to be firmly anchored in place.

Corneal shields are available in multiple sizes and may be placed over the eye to protect the cornea during periorbital procedures (Fig. 5-21). These are available both in plastic, which is both inexpensive and optimal for use during electrosurgery, and in stainless steel. Corneal shield placement requires anesthetic eye drops, careful sizing, and correct technique to avoid corneal irritation or abrasion.



Figure 5-21. Corneal shields are available in multiple sizes and may be placed over the eye to protect the cornea during periorbital procedures.

Sharps safety

The most common risk to both surgeon and assistant in dermatologic surgery is needle puncture. Thankfully, the risk of disease transmission is low when using closed-bore sewing needles. Undoubtedly, the most critical protective measure is mandatory glove use when dealing with sharps of any kind.

Loose suture needles on the surgical tray are a common source of needle injury to both the surgeon and assistant. Several systems have been developed to minimize risk. Most commonly, all sharps are kept maintained in one area of the tray. In larger cases, however, multiple needles may be used. These may be kept organized with dedicated suture needle boxes, with a disposable foam block or pincushion placed on the field, or by placing a magnet under the surgical tray to attract and organize sharps.

To avoid scalpel injury at the conclusion of a procedure, a surgical blade remover is required to separate disposable scalpel blades from the handle. The most common devices require two hands: one to hold the scalpel, and the other to operate the clamp and remove the blade (Fig. 5-22). With

practice, these are safe, reliable, and cost effective. Counter- or wall-mounted devices have also been created to allow for one-handed operation. With these devices, the scalpel is inserted, blade first, into the machine and the blade is safely removed. While efficient, these require frequent replacement.



Figure 5-22. To avoid scalpel injury at the conclusion of a procedure, a surgical blade remover may be used to separate disposable scalpel blades from the handle.

Instrument maintenance and sterilization

Careful instrument maintenance and sterilization are critical to ensure functional equipment and provide patient safety. After surgery, the instruments should be cleaned. First, all debris must be removed from the instruments. Organic debris may allow for the growth of micro-organisms, and may interfere with sterilization. This is most commonly performed by soaking followed by hand scrubbing. Ultrasonic cleaning may also be used. Next, the instruments should be dried and treated with lubricant such as instrument milk. The instruments are then packed in a self-sealing pouch, metal box, or plastic tray. They should be loosely packed, with needle

drivers and scissors in the open position. Surfaces in close contact may not be fully treated during the sterilization process. The pack should then be sterilized by steam autoclave. Though other systems, such as gas, dry heat, and chemical sterilization, are theoretically possible, these are generally less reliable and not frequently used by the dermatologic surgeon. The autoclave should be routinely tested to ensure adequate sterilization.

With appropriate maintenance, many surgical instruments may last for the career of the surgeon. Scissors may be sharpened by the manufacturer or by companies that will provide on-site service. Tungsten carbide inserts in needle drivers, scissors, and forceps may be replaced. Stiff instruments can be lubricated or cleared of mineral deposits with a solution of vinegar and water.

A basic instrument setup for dermatologic surgery procedures

- Blade handle
- Needle driver
- Suture scissors
- Tissue scissors (Supercut iris scissors used frequently)
- Forceps (Adson's with teeth and platforms used frequently)
- Hooks (optional)
- Hemostat (optional)

Instrument packs for surgery

Instruments may be packed and sterilized individually, so that the appropriate instruments may be selected for each surgical case. However, most surgeons find it more convenient to pack multiple instruments together. The most basic surgical kit can be prepared with a scalpel handle, needle driver, scissor, and forceps. Other instruments can be added as needed.

Dermatologic surgeons vary in their approach to surgical pack preparation. At one end of the spectrum, a surgeon may favor a single pack style for all surgical cases, while other surgeons utilize two types of packs (face and body) and still others use three types of packs (face, body, and

extremity). Typical surgical kits contain a scalpel handle, needle driver, tissue forceps with tying platform, a tissue-cutting scissor (either blepharoplasty, supercut iris, or both), a skin hook, a hemostat, a suture-cutting scissor, and surgical gauze. Additional specialty instruments are individually packed and available in the operating room.

CONCLUSIONS

The selection of proper surgical instruments is critical to providing high-quality, safe, and effective care in dermatologic surgery. This chapter is intended only as a guide to the overwhelming number of instrument choices available. Individual selections may be based upon the scope of procedures to be performed, the expertise and preferences of the individual surgeon, and financial limitations. Purchasing the highest-quality instruments, and correctly maintaining them, should provide long-lasting and efficient instruments.

Finally, in choosing instruments, there is no substitute for practical experience. No two surgeon's hands or skills are identical. Instrument shapes, sizes, and balances likewise vary widely. The surgeon should handle and examine a range of choices at surgical conferences or with dealer's representatives. Individual instruments can be purchased and tried before an office is fully equipped. Through experimentation and experience, comfortable and efficient instruments should be found.

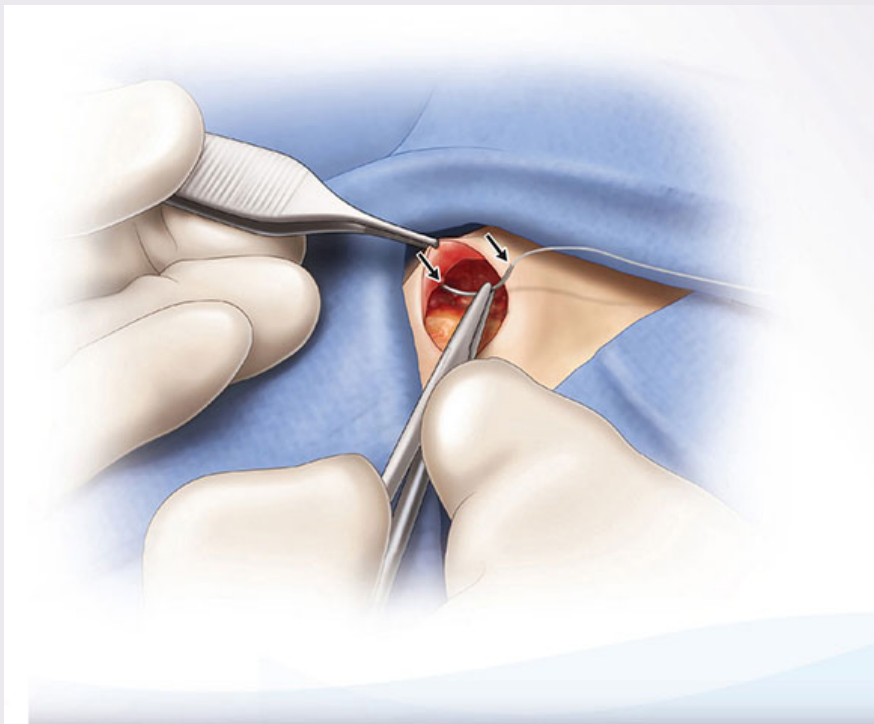
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CHAPTER 6 Suture Materials and Needles

Jonathan Kantor



SUMMARY

- Over the past several decades, suture materials have improved dramatically.
- The needle may be as or more important than the suture material itself in promoting an ideal surgical outcome.

- Keep in mind that the greatest differentiator between suture brands is needle quality rather than the suture material itself.
- Knot tying should be performed with an eye to creating a secure knot without adding undue bulk to buried sutures.

Beginner Pearls



- Most needles used for skin and soft tissue reconstruction are 3/8 circle in diameter and reverse cutting.

Expert Pearls



- A semicircular P-2 needle may be used for narrow closures, such as those sometimes encountered on the nose, and a cutting needle, with the sharp edge on the inside of the curve, may be useful for nasal reconstruction where the thin atrophic dermis may be cut by the superficially running outside edge of a reverse cutting needle.
- Since cutting and reverse cutting needles have a triangular tip, the orientation of the cutting end is indicated by whether the triangle on the box is pointing up (cutting) or down (reverse cutting).

- In order to minimize the risk of needle-stick injury, it is possible to grasp the suture material approximately 6 to 10 cm from the needle swage between the thumb and index finger of the left hand, allowing the needle to drop down below the hand. Since the needle is hanging freely and is not under tension, there is little chance for a needle-stick injury.
- Attention to technique, coupled with choice of a sufficiently large needle for the closure in question, may go a long way to optimizing surgical outcomes.

Don't Forget!



- Any suture, including absorbable sutures, may be used for transepidermal suture placement, which may permit the use of a single suture pack for both buried and epidermal sutures.

Pitfalls and Cautions



- A single click of the needle driver locking mechanism is sufficient for locking the needle, and cranking down on the needle driver excessively will result in a loosening of the locking mechanism, leading to inadvertent suture needle slippage in the future.

- The most frequent error encountered by novice dermatologic surgeons is using a needle that is too small for a given anatomic location, or using a technique that does not permit the needle to pass naturally and smoothly through tissue.
- When tying a deep suture, it is generally desirable to pull the suture strands together as tightly as possible, secured with a stable knot. For transepidermal sutures, since the goal of suture placement is wound-edge apposition, placing the minimal necessary tension across of the surface of the wound is a must; over-tightening these sutures will lead directly to strangulation, necrosis, and—at a minimum—track mark formation.

CHAPTER 6 Suture Materials and Needles

INTRODUCTION

Over the past several decades, suture materials have improved dramatically. Three thousand years ago, suture materials were composed of easily processed plant or animal materials affixed to bone or metal. In the middle ages, suture material made from sheep's intestine was introduced, and sterile catgut suture was first used in 1906. In the mid to late 20th century, advances in chemistry and manufacturing led to the production of the first synthetic sutures, and the availability of swaged needles over the past few decades has improved safety for both patient and surgeon while improving operative efficiency.

NEEDLES

A wide variety of suture materials are available, all with variable handling characteristics, tissue reactivity, absorption characteristics, and costs. While much attention is paid to suture material, the needle may be as or more important than the suture material itself in promoting an ideal surgical outcome. Needles vary by manufacturer and even by suture material, and utilizing the most appropriate needle for the task is critical. Even the most accomplished surgeon will perform in a less-than-ideal fashion if their instruments or needle choices are flawed.

Most needles used for skin and soft tissue reconstruction are 3/8 circle in diameter, and most needles used for skin and soft tissue reconstructions are reverse cutting in nature (Fig. 6-1). There are, however, important exceptions

to this rule. For example, a semicircular P-2 needle may be used for narrow closures, such as those sometimes encountered on the nose, and a cutting needle, with the sharp edge on the inside of the curve, may be useful for nasal reconstruction where the thin atrophic dermis may be cut by the superficially running outside edge of a reverse cutting needle.

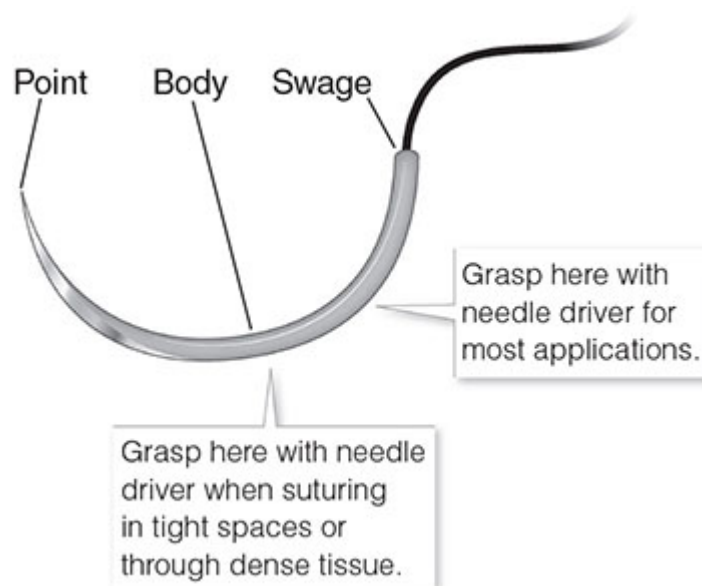


Figure 6-1. The suture needle.

The two largest manufacturers of suture material used in cutaneous surgery are Ethicon and Covidien, though many other companies produce high-quality products as well. While the suture size is governed by USP guidelines (the larger the number of zeros, the smaller the suture), needle size and configuration is largely proprietary. Thus, the surgeon must be comfortable understanding the various needle sizes and configurations of the various manufacturers. Suture material packaging does include a cross-sectional image of the needle, permitting some comparison between companies. Of note, Covidien does not (except on its website) refer to any of its needles as reverse cutting; instead, they label cutting needles as conventional cutting and reverse cutting needles as cutting. These distinctions are important when choosing suture, and many suture type and needle combinations are only available with a finite number of permutations. Since cutting and reverse cutting needles have a triangular tip, the orientation of the

cutting end is indicated by whether the triangle on the box is pointing up (cutting) or down (reverse cutting).

The material used to make the needles themselves also varies considerably between manufacturers, as proprietary alloys are used to maximize the strength and durability. While Ethicon and Covidien products are used most often in skin and soft tissue reconstruction, many other reputable companies manufacture suture material, and individual preferences may vary widely.

Suture materials

While the needle has a major effect on the ease and efficiency of the surgical procedure, suture material choice also has the potential to impact wound closure significantly. Any suture, including absorbable sutures, may be used for transepidermal suture placement, which may permit the use of a single suture pack for both buried and epidermal sutures.

Many suture characteristics are commonly discussed, including handling, memory, pliability, knot security, tissue reactivity, and others. While there are subtle differences between the handling characteristics of different suture materials, most modern options fall well within the realm of utility, so that while the handling of silk, for example, is clearly superior to the handling of nylon, even nylon handles very well. Similarly, certain materials, such as catgut, may be highly reactive, though the more frequently used formulations, such as chromic gut and fast-absorbing gut, do not lead to enough inflammation to make a marked clinical difference in most situations. For the most part, monofilament sutures lead to less tissue drag, and therefore are useful with running techniques, while braided sutures provide excellent handling and knot security, and are therefore useful for interrupted buried sutures. With improvements in materials, the distinction between outcomes now likely relates more to suturing technique than to choice in suture materials ([Table 6-1](#)).

Table 6-1. Frequently Used Suture Materials in Skin and Soft Tissue Reconstruction

Suture Material Name	Configuration	Handling	Tissue Reactivity	Loss of 50% Strength	Time to Complete Absorption
Absorbable sutures					
Vicryl (polyglactin 910)	Braided, coated	Very good	Moderate	21 days	75 days
Polysorb (glycolide/lactide polymer)	Braided, coated	Very good	Moderate	21 days	75 days
Monocryl (poliglecaprone)	Monofilament	Very good	Moderate	7 days	60 days
Maxon (polyglyconate)	Monofilament	Very good	Moderate	21 days	6 months
PDS I/II (polydioxanone)	Monofilament	Good	Moderate	30 days	6 months
Biosyn (glycomer 631)	Monofilament	Very good	Moderate	21 days	60 days
Caprosyn (polyglytone 6211)	Monofilament	Very good	Moderate	7 days	60 days
Catgut	Braided	Very good	High	Plain: 7 days Chromic: 10 days Fast absorbing: 5 days	Plain: 70 days Chromic: 84 days Fast absorbing: 35 days
Vicryl Rapide	Braided, coated	Very good	Moderate	5 days	42 days
Velosorb Fast	Braided	Very good	Moderate	5 days	42 days
Nonabsorbable sutures					
Monofilament Nylon	Monofilament	Very good	Low		
Prolene, Surgipro (polypropylene)	Monofilament	Good	Low		
Novafil (polybutester)	Monofilament	Very good	Low		
Silk	Braided	Excellent	Moderate		

Absorbable sutures

Vicryl (polyglactin 910)

Vicryl is one of the most frequently used suture materials in skin and soft tissue reconstruction. It is a braided, coated suture material that retains its strength for approximately 3 weeks and is completely absorbed in under 3 months. It has excellent handling characteristics and mild tissue reactivity. Recently, a faster-absorbing variation, Vicryl Rapide, was developed, which loses its strength entirely in under 2 weeks and may be seen as an alternative to fast-absorbing gut suture when suture removal is not desired. An antibacterial-coated variation is now also available on the market (Table 6-2).

Table 6-2. Comparison of Frequently Used Suture Materials from Ethicon and Covidien

Ethicon	Covidien	Application
Vicryl	Polysorb	Standard for buried sutures
Vicryl Rapide	Velosorb Fast	Alternative to fast-absorbing gut; excellent for skin grafts or when suture removal is not an option
Monocryl	Biosyn	Monofilament alternative for buried sutures; support is lost faster than Vicryl/Polysorb
PDS I/II	Maxon	Monofilament alternative for buried sutures; support lasts longer than Vicryl/Polysorb
Prolene	Surgipro I/II	Smooth monofilament nonabsorbable suture; excellent choice for running subcuticular sutures if suture removal is planned
Ethilon	Monosof	Standard nonabsorbable monofilament nylon suture for epidermal approximation

Note: This chart does not imply equivalency; it is designed to outline suture materials that are roughly equivalent in terms of application to skin and soft tissue reconstruction.

Polysorb (glycolide/lactide copolymer)

This is a braided absorbable suture, similar to Vicryl. It provides similar handling and knot security while ostensibly providing slightly improved initial tensile strength when compared with Vicryl. Its absorption characteristics are similar to Vicryl. Velosorb Fast has also been developed as an alternative to Vicryl Rapide.

Monocryl (poliglecaprone)

Monocryl, often seen as a monofilament alternative to Vicryl, is another popular suture material choice. It is more expensive than Vicryl, has excellent handling characteristics for a monofilament suture, and loses its strength in less than 1 month, though complete absorption takes 3 to months. As with Vicryl, an antibacterial option is also now available.

Maxon (polyglyconate)

Maxon is a long-lasting monofilament absorbable suture; while it loses some strength already after 3 weeks, it takes 6 months or more for the suture material to be entirely absorbed, making this a good choice when long-term strength retention may be helpful. It has good handling characteristics, though the slow absorption times should be taken into account if dyed suture material is used, as the suture may be visible if placed in a running subcuticular pattern.

PDS (polydioxanone)

PDS I and II are very long-lasting monofilament absorbable sutures. They are useful when long-term strength retention is critical. PDS II was developed as a better-handling alternative to PDS I, which was criticized for its less-than-ideal handling characteristics. It retains strength for an extended period of time, with 50% strength retention at 5 weeks, and may take more than 6 months to absorb.

Biosyn (Glycomer 631)

Biosyn is another monofilament absorbable suture. It has very good handling characteristics and outstanding initial tensile strength. It retains its strength

for at least 3 weeks and takes up to 4 months to absorb completely. If Biosyn is used for superficial closures, the undyed version may be preferable.

Caprosyn (Polyglytone 6211)

Caprosyn is a fast-absorbing monofilament suture, often seen as an alternative to Monocryl. It absorbs completely in 8 weeks, while retaining tensile strength for 7 to 10 days postoperatively. It is, therefore, useful in low-tension closures, such as those on the face, where rapid suture material breakdown is an advantage.

Catgut

Plain gut is derived from bovine or sheep intestines, and therefore breaks down by enzymatic degradation, rather than the hydrolysis which breaks down synthetic absorbable sutures. Chromic gut is a longer-lasting version of gut, while fast-absorbing gut is heat treated to speed up absorption. On a practical level, fast-absorbing gut may be useful for closures when transepidermal sutures are desired for wound-edge apposition but where suture removal is impractical or inconvenient. Gut does lead to more tissue reactivity than other absorbable sutures and has a tendency toward breakage after multiple passes through tissue.

Nonabsorbable

Nylon

This is a frequently used nonabsorbable suture, and provides minimal tissue reactivity coupled with very good handling. While a very good choice for most closures, it does not move through tissue as smoothly as polypropylene, so if buried subcuticular sutures are placed with nonabsorbable suture, the latter would be preferred. Nylon is available either braided or monofilament; the former may confer slightly better handling, though this is outweighed by the ability of monofilament nylon to move easily through tissue.

Polypropylene (Prolene, Surgipro)

This is a minimally reactive suture that has the ability to move smoothly through tissue. It does have a fair amount of memory, and therefore may be slightly more challenging to work with than nylon. Extra throws are often advisable during knot tying as well, though this does represent a good option for nonabsorbable subcuticular suturing.

Novafil (Polybutester)

This is a very well-handling suture material that also provides significant elasticity. While not as widely used as some other materials, it provides excellent pliability, while the elasticity may be helpful in areas where significant wound edema is anticipated, as it will accommodate tissue swelling while maintaining wound-edge apposition.

Silk

This is the most highly reactive of the nonabsorbable sutures. It also, however, is the gold standard for suture material handling. Its natural softness makes it useful in closures along the lips, where synthetic suture has a tendency to poke against the delicate tissues. Its reactivity, however, makes it less useful on a daily basis for most other surgical sites.

SURGICAL KNOT TYING

Most surgical knots in skin and soft tissue reconstruction are tied using an instrument tie. This is generally the fastest approach and also affords the least amount of suture material waste. Hand tying, using either one- or two-handed ties, may be used rarely in cutaneous surgery and reconstruction.

The distinction in knot tying between transepidermal sutures, where pulling suture tight may lead to strangulation, and buried sutures, where the goal of suture placement is developing directly opposed dermal, muscle, or fascial structures, is critical. When tying a deep suture, it is generally desirable to pull the suture strands together as tightly as possible, secured with a stable knot. For transepidermal sutures, since the goal of suture placement is wound-edge apposition, placing the minimal necessary tension across of the surface of the wound is a must; over-tightening these sutures will lead directly to strangulation, necrosis, and—at a minimum—track mark

formation. Indeed, while dermal suture placement should be performed as tight as possible, transepidermal sutures should be secured with the minimal possible tension, and indeed some additional give may be provided by permitting laxity between the first and second throws of the knot, anticipating tissue edema.

Generally, most surgical knots are tied as square knots, so that the two throws occur in opposite directions, locking the knot in place. Sometimes, a granny knot is desirable, where the first two throws are in the same direction, as this allows the suture material to be cinched down and tightened. It is critical, however, to follow the granny knot with a throw in the opposite direction so that once the knot is in place it is secured and cannot slip.

Each throw refers to one-half knot, i.e. a complete twisting of two strands. Thus to secure a knot, by definition, a minimum of two throws are necessary, and for practical purposes, three throws are used for most braided sutures, while four throws are used for some sutures with a higher risk of knot slippage.

After placement of the suture itself, when beginning an instrument tie the leading end of suture must be grasped with the nondominant hand. In order to minimize the risk of needle-stick injury, it is possible to grasp the suture material approximately 6 to 10 cm from the needle swage between the thumb and index finger of the left hand, allowing the needle to drop down below the hand. Since the needle is hanging freely and is not under tension, there is little chance for a needle-stick injury (Fig. 6-2). Excess suture material may be wrapped around the nondominant hand with a gentle turn of the wrist. Some surgeons prefer to hold the needle itself in the nondominant hand (Fig. 6-3). Recall that when placing a buried suture, the leading and trailing edges of the suture material should be on the same side of the newly created loop prior to initiating a tie.

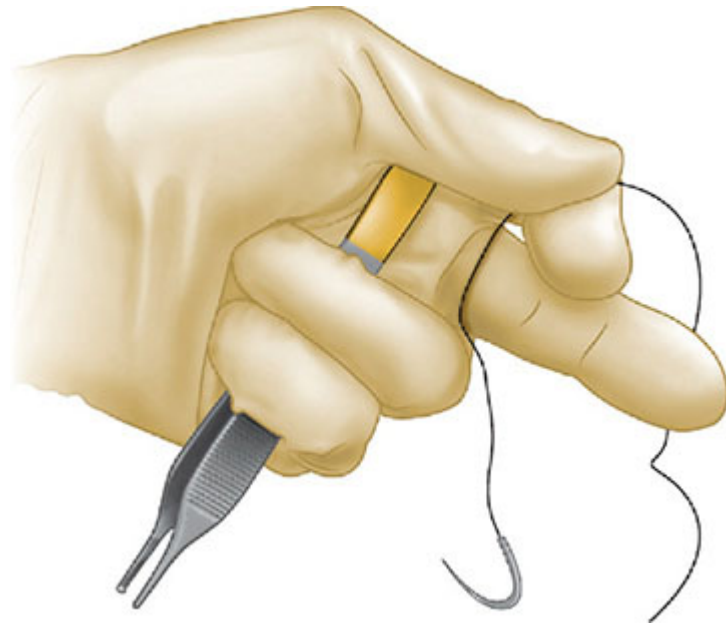


Figure 6-2. Grasping the suture material during knot tying; the suture material may be looped around the left hand if needed. Note that the needle hangs freely, without tension.

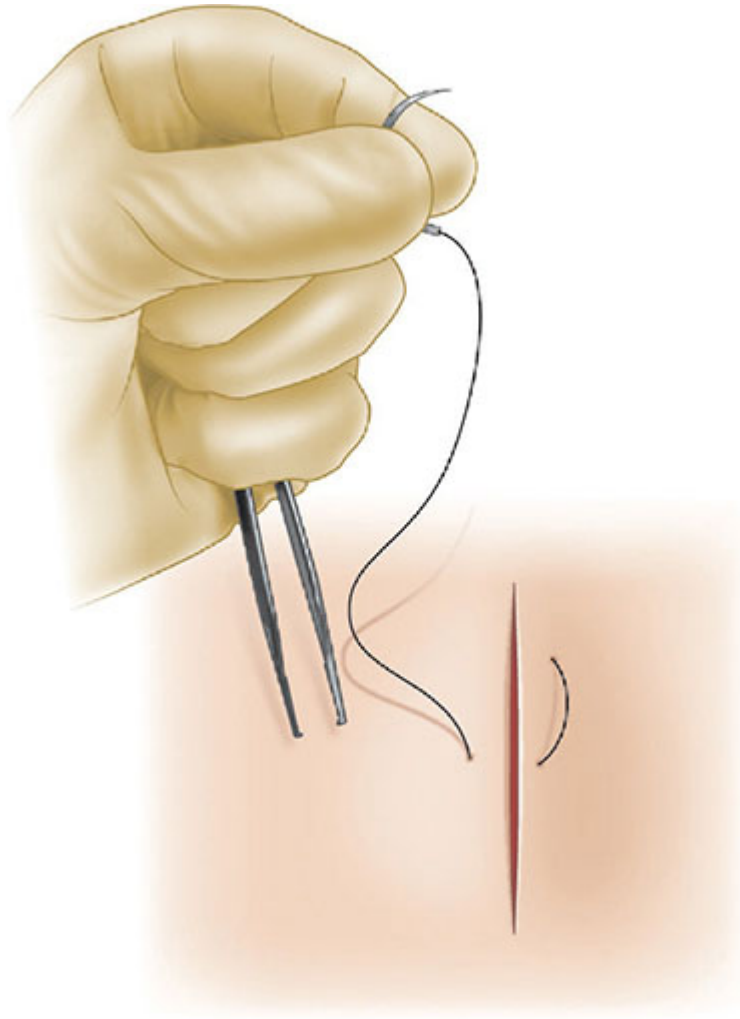


Figure 6-3. Grasping the needle during knot tying.

A single click of the needle-driver locking mechanism is sufficient for locking the needle, and indeed cranking down on the needle driver excessively will result in a loosening of the locking mechanism, leading to inadvertent suture needle slippage in the future. The needle driver may be palmed, where it is locked or released via gentle pressure from the thenar eminence, or may be held with the thumb and the fourth finger (Figs. 6-4 to 6-9). When delicately placing fine-gauge sutures in the face, the body of the needle driver may be held with the thumb, the first finger, and the second finger, and delicately rotated through the skin, permitting precise placement of fine sutures.

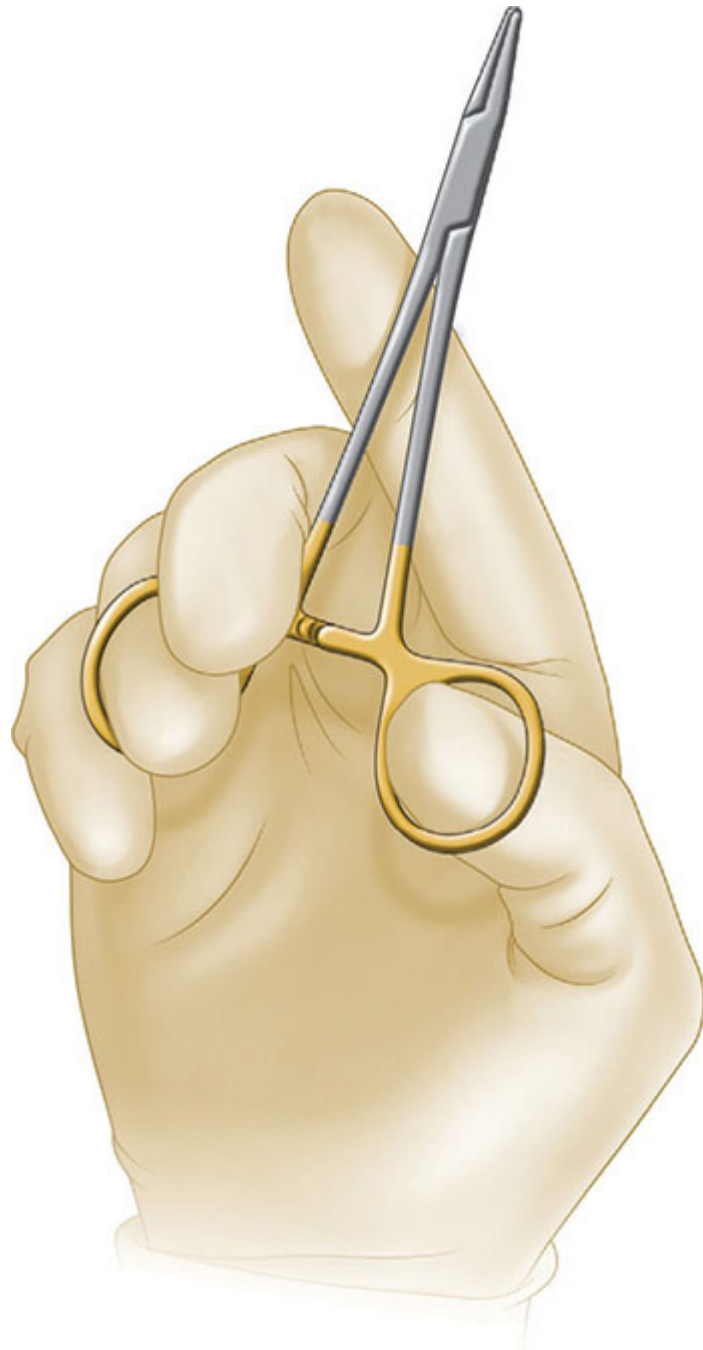


Figure 6-4. The basic needle-driver grasping position, with the thumb and fourth finger in the rings.

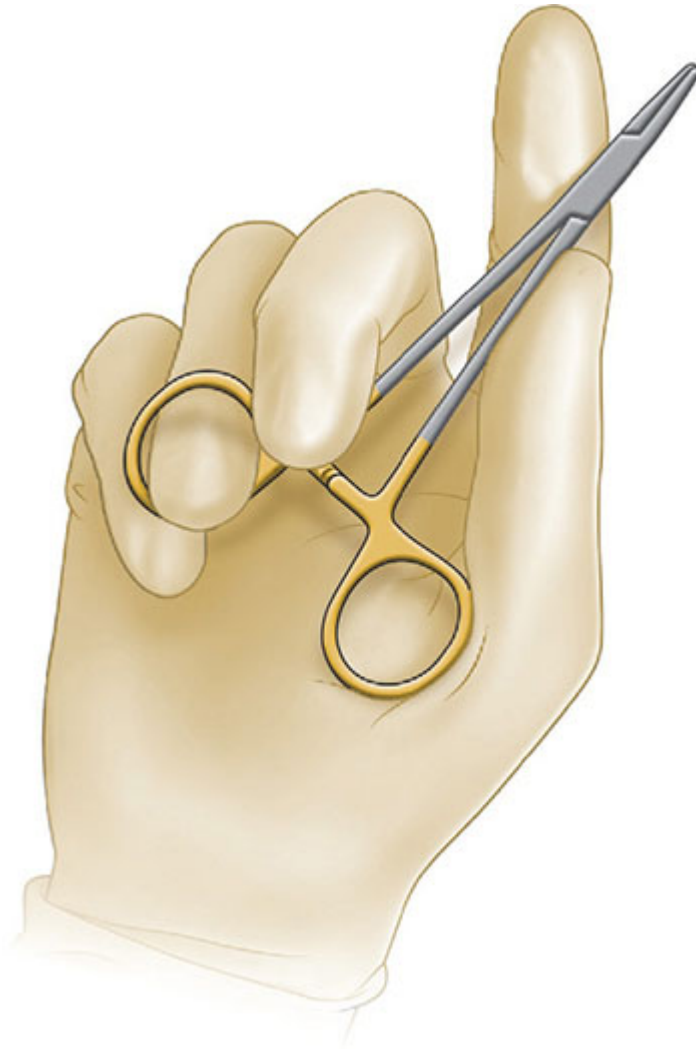


Figure 6-5. Palming the needle driver. This is the default position for many surgeons. The fourth finger may rest slightly on the inside of the ring.



Figure 6-6. Palming the needle driver with no fingers in the rings.

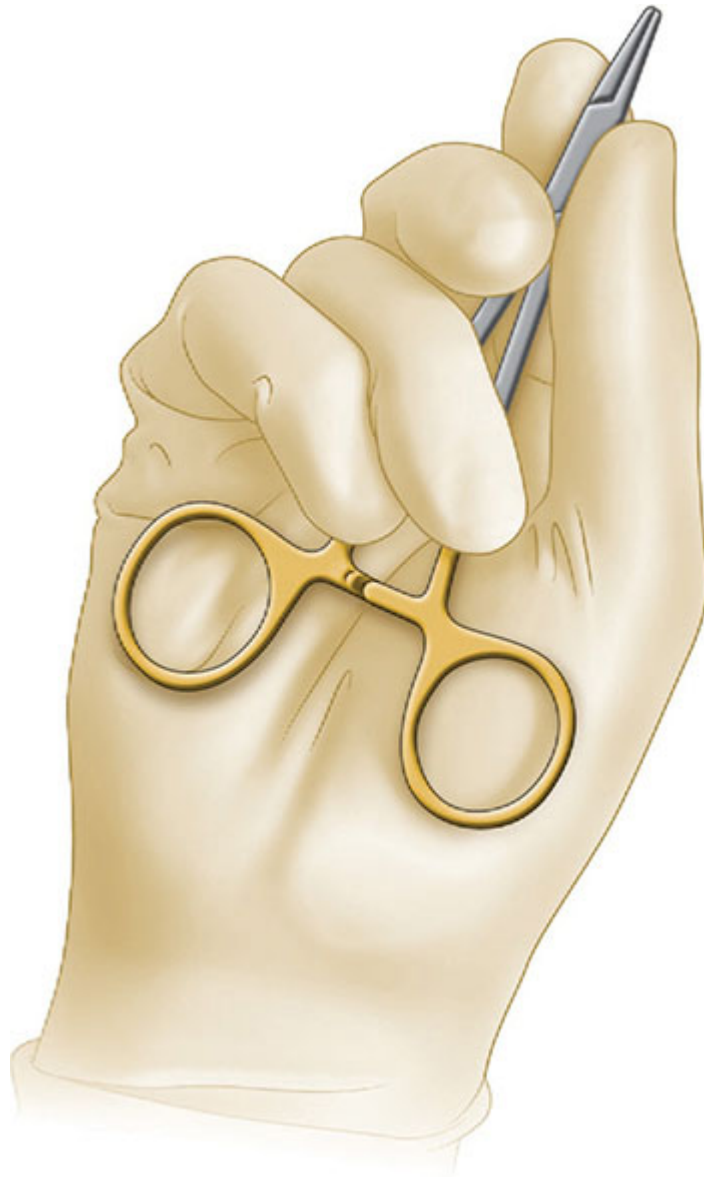


Figure 6-7. Needle-driver grasping position when performing fine suturing.

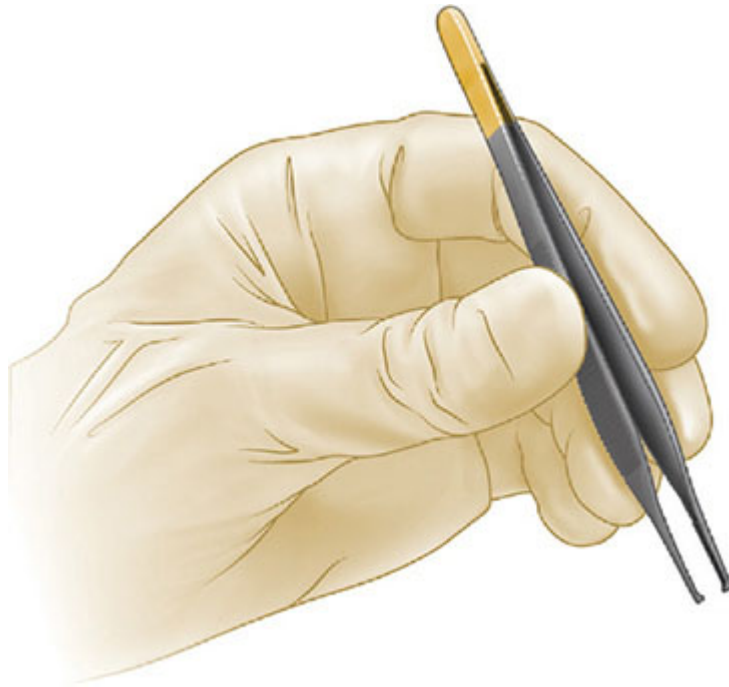


Figure 6-8. Holding the forceps for tissue or needle handling.



Figure 6-9. Palming the forceps to free up the fingers for grasping suture material and knot tying.

When grasping the needle body with the needle driver, the default position is to grasp the needle with the end of the needle driver perpendicular to the body of the needle approximately one-third of the distance from the swage where the suture material is bonded to the needle. When first loading a needle, this may be executed by gently pressing the slightly open jaws of the needle driver perpendicularly against the needle and closing the needle driver with a single click. For closures in tight spaces, the needle may be grasped toward the middle or even slightly distally so that the arc of needle placement is relatively shallow, while for other select closures, such as the running subcuticular technique, the needle may be held at an angle relative to the jaws of the needle driver.

Technique for performing an instrument tie with nonabsorbable sutures:

- (a) The leading end of suture material is grasped between the thumb and the index finger of the left hand, approximately 6 cm from the needle swage. The needle driver is brought between the leading and trailing strands of suture, and the leading end of suture is wrapped twice around the needle driver. This should be done by moving the needle driver around the suture, not moving the suture material around the needle driver, as this will permit better precision and economy of movement.
- (b) The needle driver then grasps the trailing end of suture material.
- (c) The hands are pulled in opposite directions, perpendicular to the incised wound edge, so that the right hand moves to the left (where the leading end of suture began) and the left hand moves to the right (where the trailing end of suture began). This should form a surgeon's knot that will be resistant to slippage.
- (d) The trailing end of suture is released by the needle driver, and the needle driver is then brought from the inside, between the two ends of suture, and the leading end of suture is wrapped once around the needle driver.
- (e) The hands again move in opposite directions, so that now the right hand moves to the right and the left hand moves to the left. The knot is now locked.
- (f) For the third (and often final) throw, steps (a) through (c) are then repeated. Additional throws may be placed if needed (Figs. 6-10 to 6-17).

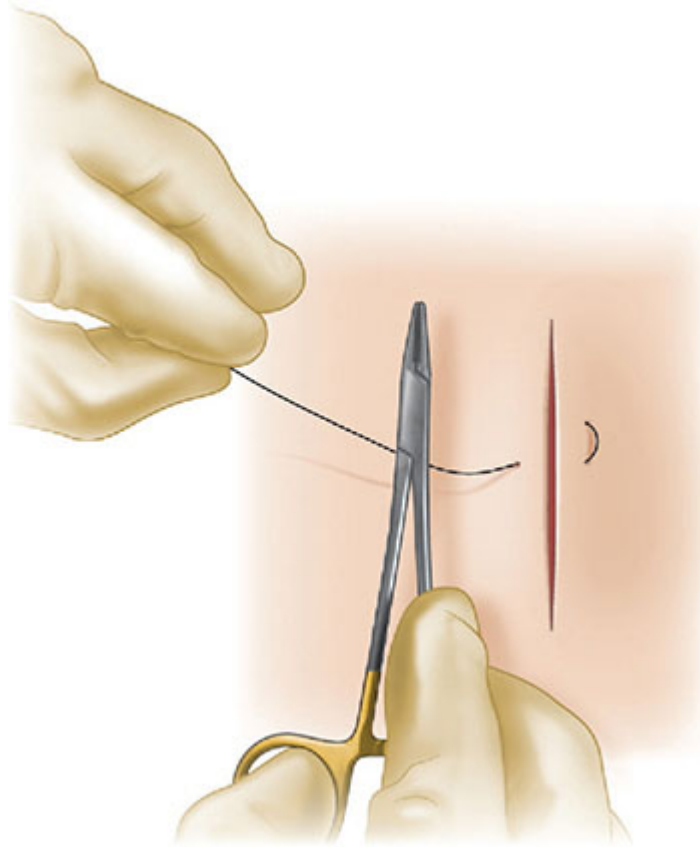


Figure 6-10. The instrument tie for nonabsorbable suture material. Step 1: The needle driver is brought between the leading and trailing strands of suture.

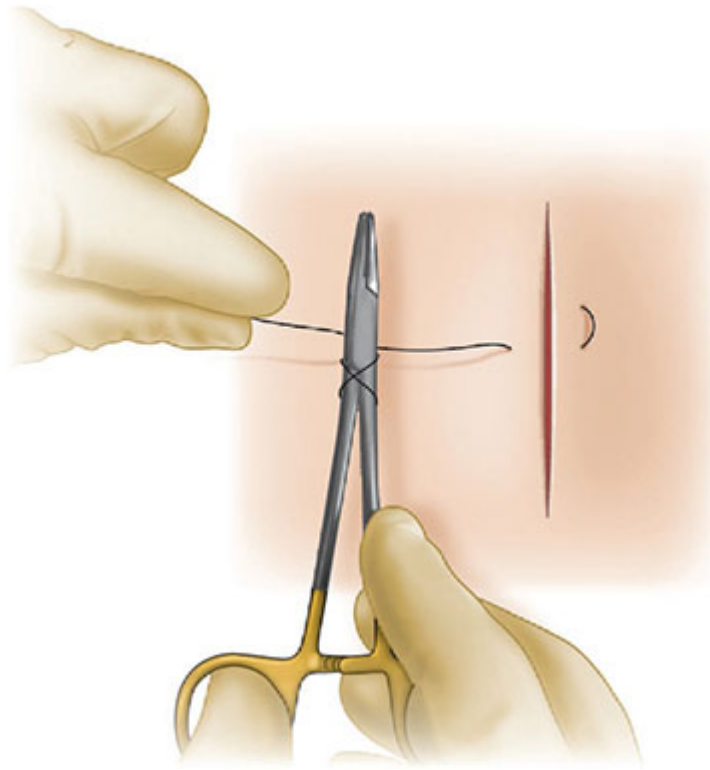


Figure 6-11. Step 2: The suture material is looped twice around the needle driver by rotating the needle driver around the suture material.

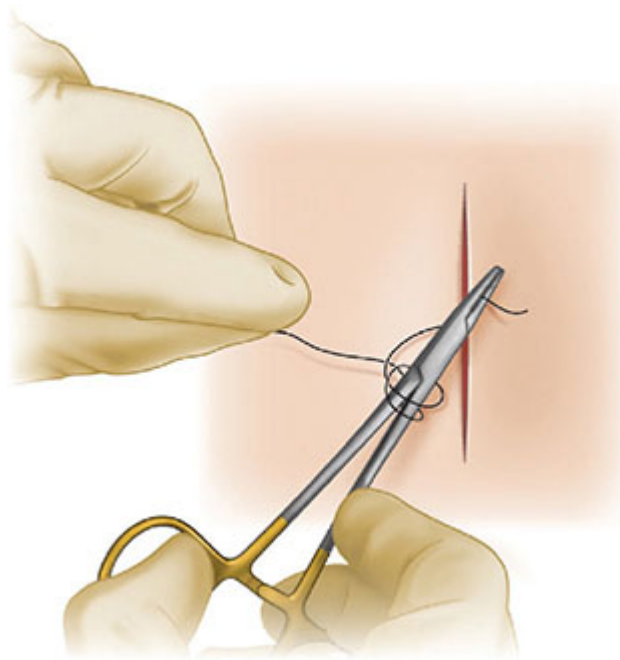


Figure 6-12. Step 3: The needle driver is then used to grasp the tail of the suture material.

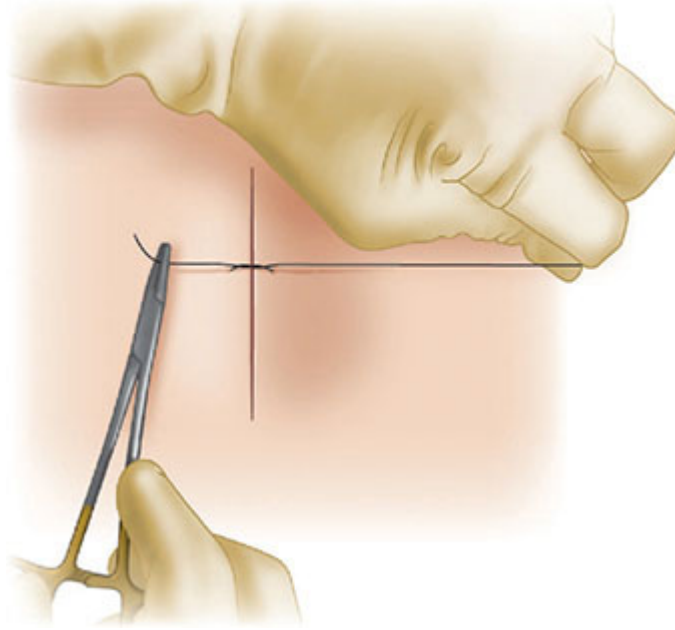


Figure 6-13. Step 4: The two ends of suture are pulled in opposite directions, perpendicular to the wound, allowing the knot to lay flat.

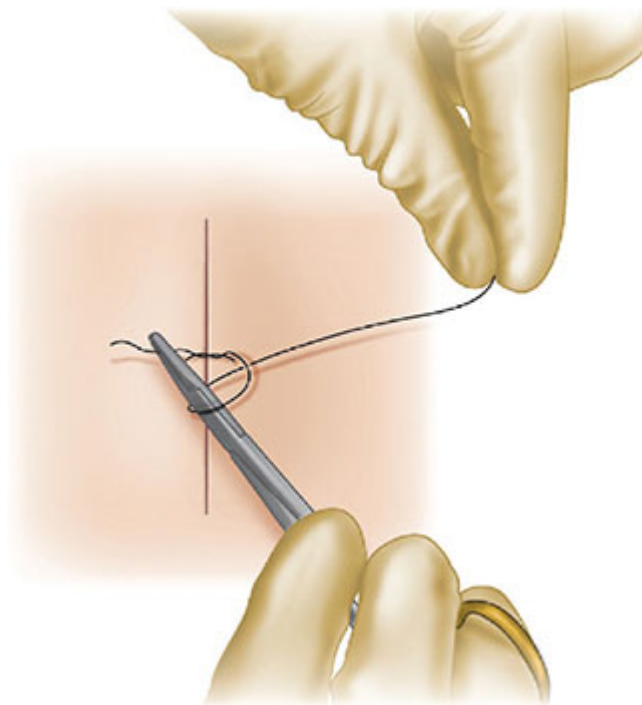


Figure 6-14. Step 5: The needle driver is then again brought between the ends of suture, and the leading end of suture material is wrapped once around the needle holder, and the trailing tail is grasped.

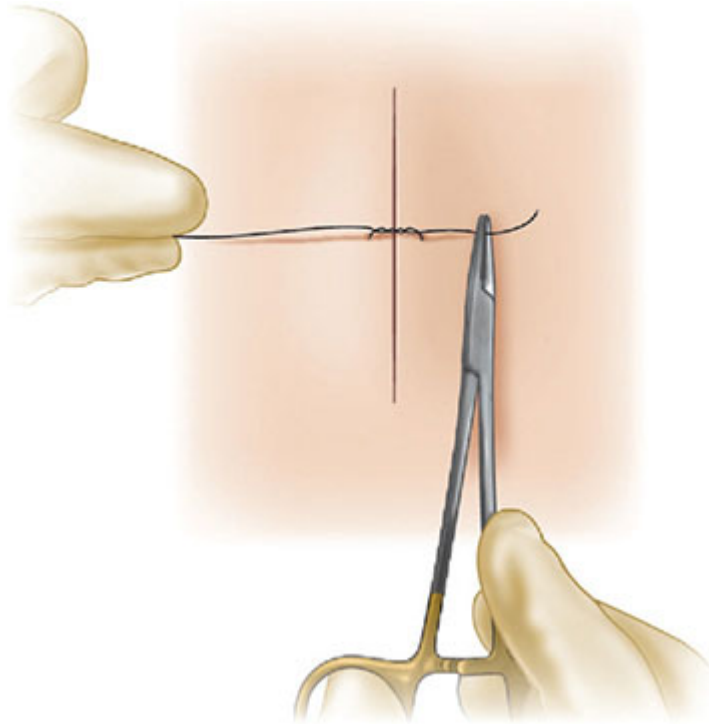


Figure 6-15. Step 6: The two ends of suture are again pulled apart, now moving in the direction opposite the prior throw, again perpendicular to the wound edge.

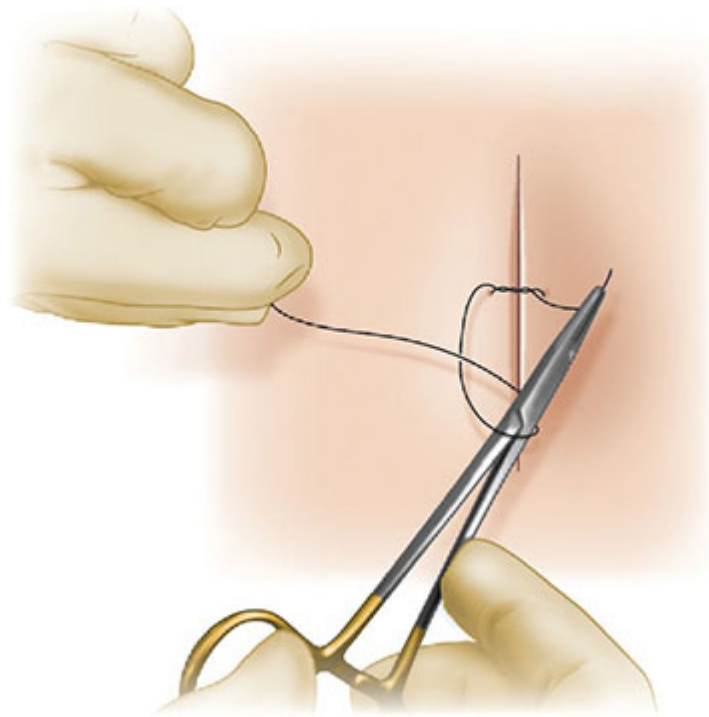


Figure 6-16. Step 7: For the third throw, the procedure is repeated again with the needle driver brought between the two strands, the needle driver wrapping the leading end of suture around itself once, the trailing end is grasped.

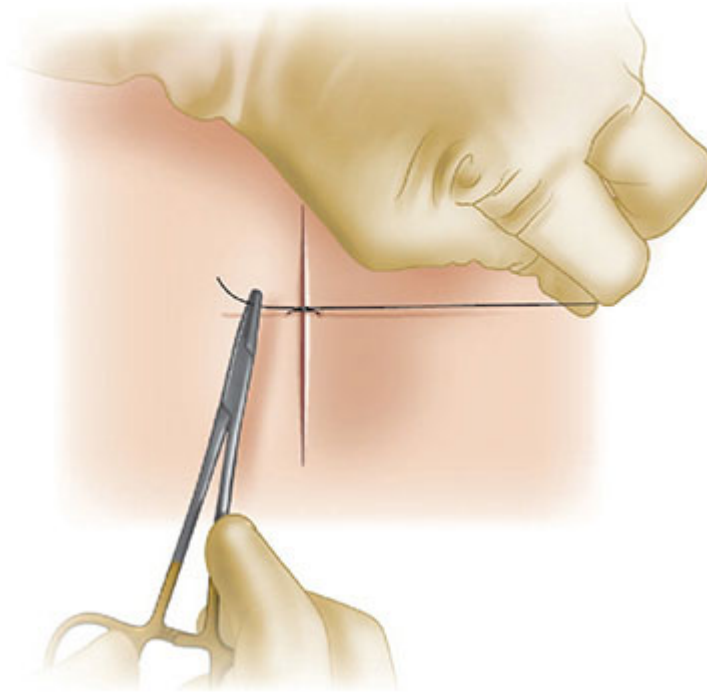


Figure 6-17. Step 8: The hands are then pulled in opposite directions, pulling the throw tight and securing the knot. For the most braided suture materials, three throws is adequate, while for some monofilament suture, a fourth throw may be added.

Technique for performing an instrument tie with buried sutures:

- (a) The leading end of suture material is grasped between the thumb and the index finger of the left hand, approximately 6 cm from the needle swage. The needle driver is brought between the leading and trailing strands of suture, and the leading end of suture is wrapped twice around the needle driver. This should be done by moving the needle driver around the suture, not moving the suture material around the needle driver, as this will permit better precision and economy of movement.
- (b) The needle driver then grasps the trailing end of suture material.
- (c) The hands are pulled in opposite directions, parallel to the incised wound edge, so that the right hand moves in the direction of where the leading end of suture began, and the left hand moves in the direction of where the trailing end of suture began. This should form a surgeon's knot that will be resistant to slippage.

- (d) The trailing end of suture is released by the needle driver, and the needle driver is then brought from the inside, between the two ends of suture, and the leading end of suture is wrapped once around the needle driver.
- (e) The hands again move in opposite directions parallel to the wound, so that the right hand moves in the direction of where the leading strand began and the left hand moves in the direction of where the trailing strand began. The knot is now locked.
- (f) For the third (and often final) throw, steps (a) through (c) are then repeated. Additional throws may be placed if needed (Figs. 6-18 to 6-25).

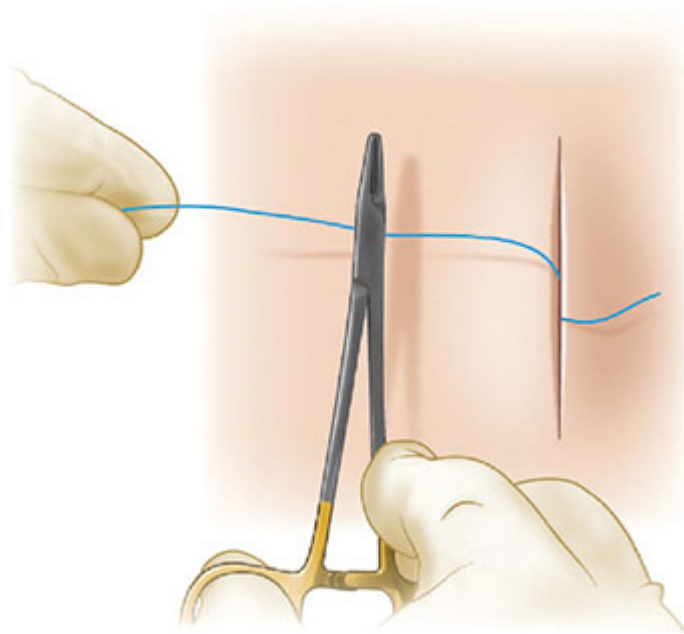


Figure 6-18. The instrument tie for absorbable suture material. Step 1: The needle driver is brought between the leading and trailing strands of suture.

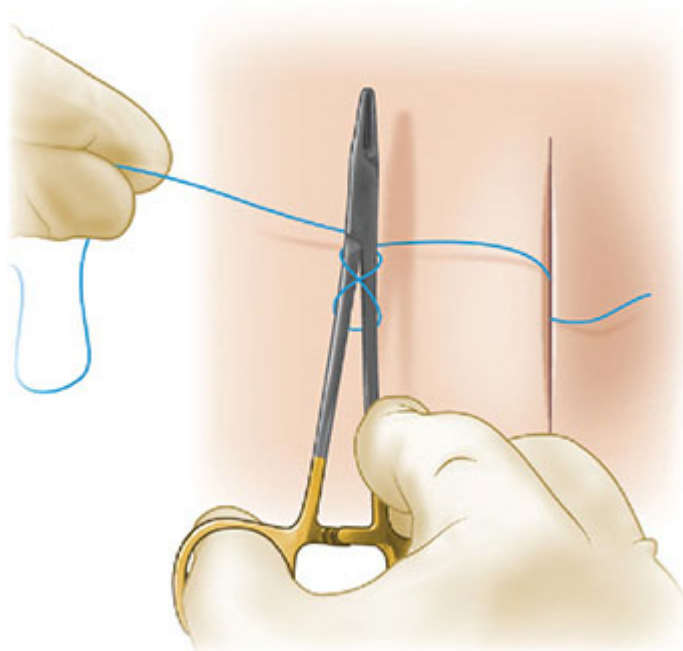


Figure 6-19. Step 2: The suture material is looped twice around the needle driver by rotating the needle driver around the suture material.

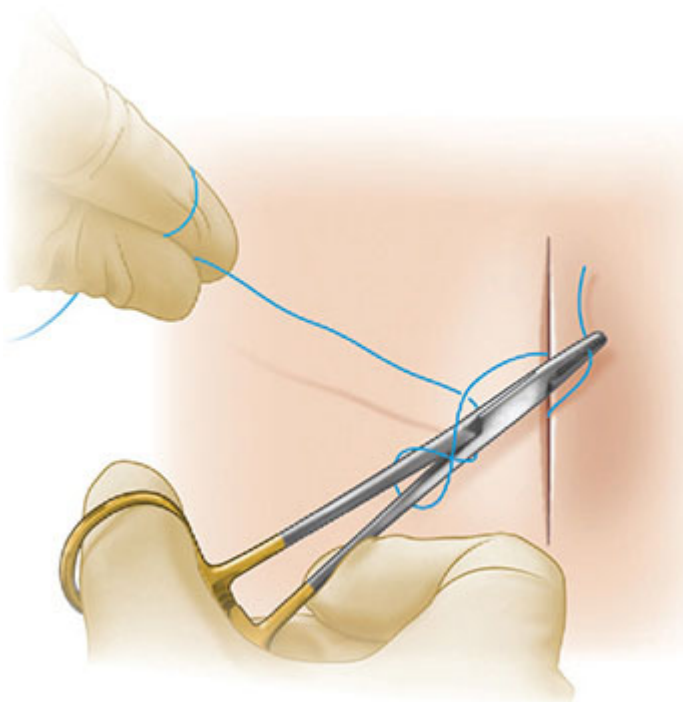


Figure 6-20. Step 3: The needle driver is then used to grasp the tail of the suture material.

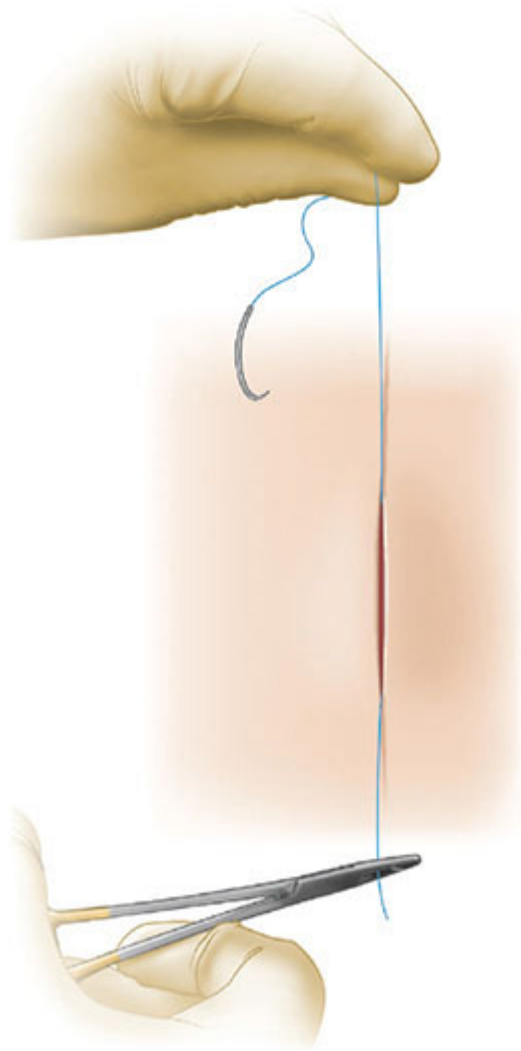


Figure 6-21. Step 4: The two ends of suture are pulled in opposite directions, parallel to the wound, allowing the knot to lay flat.

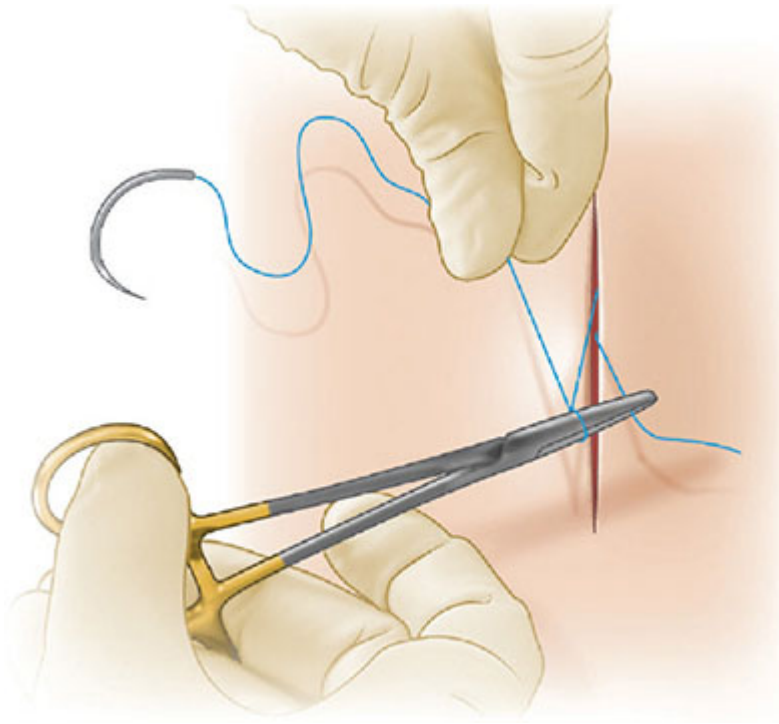


Figure 6-22. Step 5: The needle driver is then again brought between the ends of suture, and the leading end of suture material is wrapped once around the needle holder, and the trailing tail is grasped.

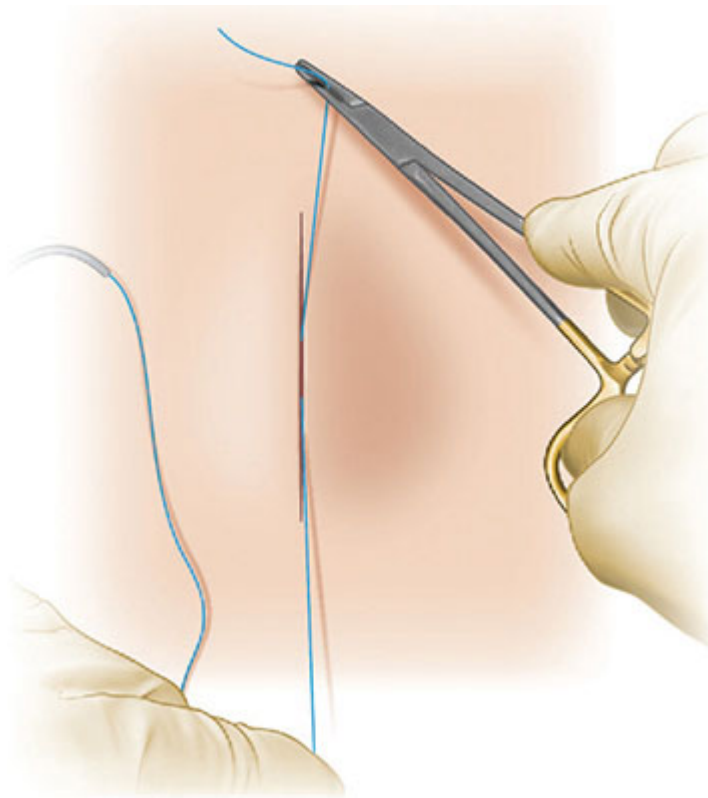


Figure 6-23. Step 6: The two ends of suture are again pulled apart, now moving in the direction opposite the prior throw, again parallel to the wound edge.

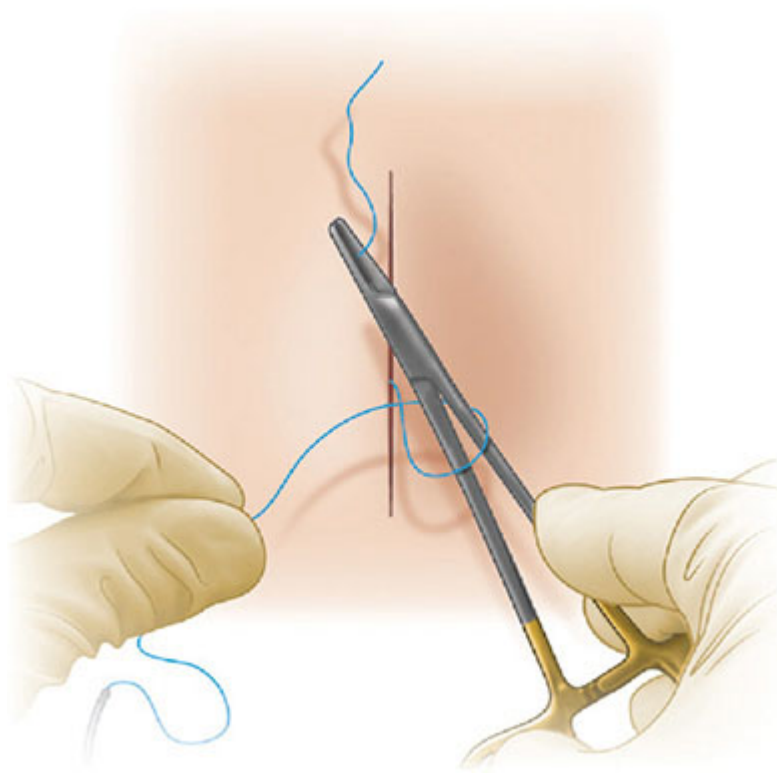


Figure 6-24. Step 7: For the third throw, the procedure is repeated again with the needle driver brought between the two strands, the needle driver wrapping the leading end of suture around itself once, the trailing end is grasped.

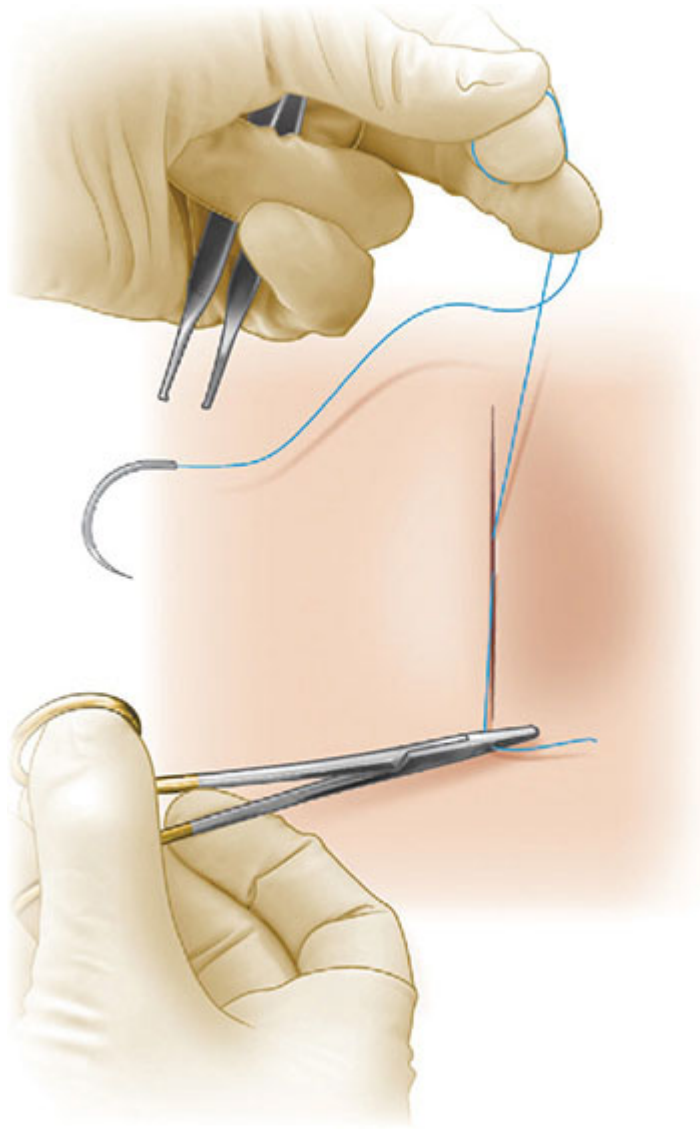


Figure 6-25. Step 8: The hands are then pulled in opposite directions, parallel to the wound axis, pulling the throw tight and securing the knot. For most braided suture materials, three throws is adequate, while for some monofilament suture a fourth throw may be added.

Absorbable suture material is generally trimmed either at the knot (for braided suture material) or with a 1- to 2-mm tail of suture, for monofilament suture material. Nonabsorbable sutures are generally left with a 3- to 6-mm tail, depending on surgeon preference, suture material size, and the anatomic location.

When tying knots with nonabsorbable suture, if there is only minimal tension across the surface of the wound, it is sometimes desirable to leave a gap between the initial surgeon's knot and the square not. To execute this

maneuver, the first throw is placed as a surgeon's knot. The next throw is not tightened to lock the surgeon's knot, but rather leaves 1 to 2 mm of space between the surgeon's knot throw and the subsequent throws. This allows for some give so that tissue edema does not cause the suture material to overly constrict the wound edges (Table 6-3).

Table 6-3. Comparison of frequently used reverse cutting needles from Ethicon and Covidien

Ethicon	Covidien
P-1	P-10
P-3	P-13
PS-1	P-14
PS-2	P-12
CP-2	GS-10
FS-1	C-14
FS-2	C-13
P-2	P-21

Note: Comparison does not imply equivalency, as the alloy and finish quality within and between companies will vary. All are 3/8 circle in diameter except the P-2/ P-21 which are ½ circle.

CONCLUSIONS

Historically, much attention has been paid to the various characteristics of suture materials, such as memory and handling, though most modern suture materials are so easy to use that these differences largely become matters of individual taste and preference. High-quality suture material used on a high-quality needle permits the facile placement of the large numbers of suture throws that are common in dermatologic surgery. In general, the choice of needle and suture material gauge, rather than suture material itself, may contribute more to the success of an individual procedure. The most frequent error encountered by novice dermatologic surgeons is using a needle that is too small for a given anatomic location, or using a technique that does not permit the needle to pass naturally and smoothly through tissue. Therefore,

attention to technique, coupled with choice of a sufficiently large needle for the closure in question, may go a long way to optimizing surgical outcomes.

CHAPTER 7 Antibiotics: Preoperative and Postoperative Considerations

Allen F. Shih
Jonathan Kantor

SUMMARY

- The rate of infection after skin surgery is likely between 1% and 4%.
- Antibiotic use in dermatologic surgery has declined markedly over the past several decades, as studies highlighting the baseline low rate of wound infections, coupled with the individual and societal risks associated with widespread antibiotic use, have made the routine prescribing of perioperative antibiotics no longer the standard of care.

Beginner Pearls



- The differential diagnosis of postoperative infection includes irritant or allergic contact dermatitis, suture reactions/suture abscesses, filler reactions (if relevant), and inflammatory chondritis.
- Contact dermatitis should be considered, particularly when topical antibiotics or adhesives were used, or when the involved area is geometric.

Expert Pearls



- Risk factors for infection include patient factors, surgical factors, and surgical site factors.
- One study demonstrated a statistically significant benefit to local intra-incisional clindamycin injection for Mohs micrographic surgery cases; the solution was prepared by adding 0.15 mL of clindamycin (150 mg/mL) to a 50-cc bottle containing lidocaine (1%) with epinephrine (1:100,000) buffered with sodium bicarbonate (5 mL of an 8.4% solution)

Don't Forget!



- Cephalexin or dicloxacillin can be used as prophylaxis for wedge excisions of the lip or ear, flaps on the nose, and grafts.
- Clarithromycin, levofloxacin, TMP-SMX, metronidazole, and ciprofloxacin are associated with a higher risk of hypoglycemia in diabetic patients taking sulfonylurea medications.

Pitfalls and Cautions



- While antibiotics are typically given the hour before the procedure, there is ambiguous data about whether prophylactic antibiotic timing affects the risk of SSI.
- Given the high rate of warfarin and sulfonylurea use in the patient population undergoing dermatologic surgery, systemic antibiotics should be prescribed with extreme caution and an eye to minimizing the risk of drug–drug interactions.

Patient Education Points



- No rigorous study has demonstrated a robust statistically significant benefit to utilizing any single topical antibiotic preparation, and the American Academy of Dermatology has, therefore, warned against the routine use of topical antibiotics after clean surgical procedures as part of its Choosing Wisely campaign.

- Patients often request perioperative antibiotics under the assumption that these will decrease their risk of developing an infection; therefore, adequate education may be valuable in dissuading patients from this practice and increasing their comfort level.
- It may be helpful to explain to patients that bacteremia is more likely after brushing their teeth than it is postoperatively.

CHAPTER 7 Antibiotics: Preoperative and Postoperative Considerations

INTRODUCTION

Antibiotic use in dermatologic surgery has declined markedly over the past several decades, as studies highlighting the baseline low rate of wound infections, coupled with the individual and societal risks associated with widespread antibiotic use, have made the routine prescribing of perioperative antibiotics no longer the standard of care. Dermatologic surgeons must understand the subtleties of antibiotic choice not only to guide clinical patient management, but also to elegantly explain to patients why they would—or would not—benefit from antibiotic use in the perioperative period. An anxious patient can often be easily calmed by providing a reasoned explanation of the scientific basis of the surgeon's decision to decline a patient-suggested antibiotic prescription. Understanding both the scientific literature as well as society-level recommendations regarding antibiotic use is, therefore, useful both for patient care and patient peace of mind.

EPIDEMIOLOGY

The rate of infection after skin surgery is likely between 1% and 4%,^{1–4} varying based on the type of surgery and risk factors for infection. Rates of

infection after Mohs micrographic surgery, excisions, full-face CO₂ resurfacing, and flaps range from 0.7% to 3%; these numbers generally increase with the complexity of the surgical procedure (Table 7-1).⁵ The infection rate for Mohs surgery without prophylactic antibiotics has been reported at under 1%.⁴ There are significant differences in the rates of infection depending on anatomical site and patient risk factors, with repairs on the genitalia, ears, or lower extremities, or in those with other risk factors, such as diabetes, associated with an increased risk of infection.²

Table 7-1. Incidence of Infections in Dermatology Procedures⁵

Incidence of Infections in Dermatologic Procedures	
Procedure	Overall Infection Rate (%)
Mohs micrographic surgery	0.7–2.3
Excisions	1.9–2.3
Full face CO ₂ resurfacing	1.1–7.6
Flaps	3

Data from Shurman DL, Benedetto AV: Antimicrobials in dermatologic surgery: facts and controversies, *Clin Dermatol*. 2010 Sep-Oct;28(5): 505–510.

Despite the low incidence of infections, when they do occur, surgical site infections (SSI) can lead to severe complications.⁶ In dermatologic surgery, serious adverse events occur in only 0.02% of cases, though the rate of postsurgical acute care visits attributed to SSIs in ambulatory surgical centers is around 0.5% in the 30 days after surgery.⁷ Moreover, skin surgery infection rates are likely several-fold higher in developing nations, as the burden of overall healthcare-associated infections in resource-limited settings is three times higher than the infection rates in developed countries.⁸

Surgical site infections—clinical features and diagnosis

SSIs, while generally mild in nature, may lead to severe complications, including bacterial endocarditis and prosthetic joint infection. As defined by

the Centers for Disease Control and Prevention (CDC), SSIs are infection occurring within 30 days of the procedure, involve only the skin and subcutaneous tissue at the incision, and include one of the following four criteria: purulent drainage from the incision site; positive microbiologic testing from an aseptically obtained specimen; presence of pain or tenderness, localized swelling, erythema, or heat; or diagnosis of SSI by a physician (Table 7-2).⁹ SSI typically occurs in the first 2 weeks after the procedure.

Table 7-2. Superficial Incisional Surgical Site Infection Definition from the CDC

Superficial Incisional Surgical Site Infection (SSI)

Within 30 days after operative procedure

(day 1 = procedure date)

Involves only skin and subcutaneous tissue of incision

One of the following:

1. Purulent drainage from superficial incision
2. Positive microbiologic testing (either culture or nonculture test) from aseptically obtained specimen for purposes of clinical diagnosis or treatment
3. Superficial incision that is deliberately opened by surgeon and culture- or nonculture-based testing is not performed

AND

At least one of the following: pain or tenderness; localized swelling; erythema; heat

4. Diagnosis of superficial incisional SSI by surgeon or attending physician

Reproduced with permission from Centers for Disease Control and Prevention (CDC). <https://www.cdc.gov/nhsn/pdfs/pscmanual/9pscscssicurrent.pdf>.

The presentation of SSIs can mimic that of other conditions, and the differential diagnosis may include irritant or allergic contact dermatitis, suture reactions/suture abscesses, filler reactions (if relevant), and inflammatory chondritis. Contact dermatitis should be considered

particularly when topical antibiotics or adhesives were used, or when the involved area is geometric. Suture irritation can lead to suture granuloma/suture abscess formation, essentially a foreign body reaction that provokes local inflammation. However, suture granuloma will be culture negative and occurs only in the areas surrounding the suture material itself. If fillers are used, inflammatory reactions to these foreign materials can produce swelling, erythema, and change in color.¹⁰ Filler-induced complications include dermal nodules, abscesses, or delayed hypersensitivity manifesting as erythematous subcutaneous nodules.¹¹ Detailed patient history can elicit a history of previous soft-tissue augmentation, though patients may not be forthcoming about nonapproved fillers. Biopsy can provide a definitive diagnosis.¹² Finally, in surgical cases involving cartilage, chondritis can mimic SSI with pain, tenderness, and erythema, though it will be culture negative. This is a fairly common phenomenon, as in one study the incidence of inflammatory chondritis after post-Mohs reconstruction was around 5.6%.¹³ The risk of suppurative chondritis, a disfiguring condition involving liquefactive necrosis of the cartilage (particularly involving the ear), can be prevented with perioperative antibiotics with antipseudomonal coverage such as ciprofloxacin.¹³

Delayed reactions should raise the possibility of an infectious process involving biofilms, particularly after procedures involving fillers.¹² Biofilms are polymeric structures produced by bacterial colonies that adhere to surfaces.¹⁴ These self-protective films can thwart normal immune system responses and reduce susceptibility to antibiotics by altering the local microenvironment and employing protective signaling pathways.¹⁵ The NIH estimates that up to 80% of human bacterial infections overall are associated with biofilms. Biofilms are associated with particular bacteria, including *Staphylococcus epidermidis*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Escherichia coli*.¹⁵ Bacteria form biofilms upon lack of prompt antibiotic treatment and inappropriate use of steroids and NSAIDs. These biofilms are often culture negative and need to be further investigated with fluorescence *in situ* hybridization (FISH) directed against bacterial DNA.¹⁶

Wound classification and infection risk

Wounds can be differentiated into four types—Class I, Class II, Class III, and Class IV—based on the degree of contamination and inflammation in the wound (Table 7-3).¹¹ Wounds that are clean and uninfected, without any break in surgical sterile technique, show less than 5% risk of infection and do not require antibiotics. Class II wounds are clean-contaminated, including wounds that are intended to heal by secondary intention, and entail a 10% risk of SSI. Class III wounds are contaminated and nonpurulent traumatic wounds with an elevated 20% to 30% risk of infection, requiring antibiotics. Class IV infections include wounds with purulent inflammation or presence of foreign body, which is reported to have an infection risk around 30% to 40% and require antibiotics. Almost all dermatologic surgery wounds are therefore Class I wounds.

Table 7-3. Risk of Surgical Site Infection for Wounds Based on Classes I, II, III, and IV

	Class I	Class II	Class III	Class IV
Label	Clean	Clean-contaminated	Contaminated	Dirty-infected
Description	Uninfected wounds	Entry in oral cavity, axilla, inguinal area	Acute traumatic wounds that are nonpurulent	Purulent inflammation with necrosis, foreign body
Risk of SSI	<5%	10%	20–30%	30–40%
Antibiotics	None	Case-by-case	Antibiotics	Antibiotics

Data from Rossi AM, Mariwalla K. Prophylactic and empiric use of antibiotics in dermatologic surgery: A review of the literature and practical consideration, *Dermatol Surg*. 2012 Dec;38(12):1898–1921.

RISK FACTORS FOR INFECTION

Numerous risk factors impact the likelihood that a patient will develop an SSI postsurgery (Table 7-4).¹⁷ These risk factors can be stratified as patient factors, surgical factors, and surgical site factors. Patient factors include poor nutritional status, immunosuppression, presence of certain comorbidities, concurrent infection, and drug use. Autoimmune diseases, such as rheumatoid arthritis, systemic lupus erythematosus, or drug- or radiation-induced immunosuppression can increase the likelihood of developing a postoperative infection. Concurrent inflammation and infection elsewhere can increase risk of infection as well, and nonemergent dermatologic surgery should be delayed until such conditions are resolved. Comorbidities that increase the rate of SSI include chronic renal disease, peripheral vascular disease, and obesity.¹⁸ Although increased prevalence of comorbidities in older adults may be a confounding factor, increasing patient

age is independently associated with increasing infection risk after dermatologic surgery.^{19,20} While well-controlled diabetes mellitus does not lead to increased risk of wound infections, poorly controlled diabetes results in abnormal glucose levels that increase the risk of wound infections.²¹ Tobacco use is associated with higher incidence of postoperative complications such as wound dehiscence, flap or graft necrosis, prolonged healing time, and infection.²² Wound complications after biopsies occur more frequently in smokers and patients taking corticosteroids.²³

Table 7-4. Risk factors for SSI

Patient	Surgical Technique	Surgical Site
Nutritional status	Complexity (grafts, flaps, wedge excisions)	Ear
Immunosuppression	Hemorrhage	Groin
Concurrent infection	Longer duration	Axilla
Drug use	Multiple stages	Lower extremity
Tobacco use	Poor tissue handling	Nose
Autoimmune disease	Instrument handling	
Radiation		
Renal disease		
Peripheral vascular disease		
Obesity		
Poorly controlled diabetes		
Advanced age		

Surgical risk factors include high degree of surgical complexity, procedures with greater likelihood of hemorrhage, poor surgical technique, long surgical duration, large postoperative surgical defects,² and poor follow-up care. Hemorrhage can lead to local pooling of blood, creating a

suitable local environment for the replication of bacteria. It is important that dermal and subcutaneous defects are minimized with close approximation of edges, as the lack of subcutaneous sutures after excisional procedures has been associated with an increased rate of wound complications.²³ During surgery, crush tissue injury from forceps can predispose to local necrosis and subsequent infection. Moreover, longer duration of surgery, including the multiple stages sometimes required for Mohs surgery, may lead to reduced sterility of the surgical site as the patients transfer between the operating area and the waiting room.⁴ Longer operative times correlate with increased infection rates, with an approximate doubling of risk with each additional hour of surgery. Poor surgical technique and improper instrument handling and sterilization represent additional potential causes of wound contamination.

More complex dermatologic procedures have higher rates of infection than simpler procedures. Punch and shave procedures of the skin not involving mucous membranes do not require antibiotic prophylaxis. While noninvasive laser treatments also do not require prophylaxis, laser resurfacing and other procedures damaging the epidermis on a larger scale can lead to a larger and deeper wound area. More complex procedures, such as grafts, wedge excisions, and flaps are all associated with higher levels of infection risk.²¹ While surgical technique is very important, improper wound dressing and inadequate postoperative care could be a source of infection. Despite these risk factors, it is important to remember that the overall rate of infection in dermatologic surgery remains low.

Surgical site factors refer to the anatomical site of the procedure. Different sites can lead to differing levels of immune defense and can be associated with increased prevalence of bacteria. Lack of perfusion and adequate bloody supply can predispose a surgical site to infection. For example, ear procedures involving cartilage, which lacks an intrinsic vascular supply, are associated with a fourfold higher incidence of wound infection compared to Mohs procedures elsewhere.² Similarly, suboptimal circulation in the nose⁴ and lower extremities, particularly in patients with peripheral arterial disease, may lead to an increased risk of infection.²¹ As the bacterial flora vary by anatomical location, the same surgical procedure can have very different infection rates depending on the surgical site.

Surgical sites in areas below the waist, in the groin, and in areas with many sebaceous glands and hair are associated with increased infection.²¹

Minimizing infectious risk of SSI

Risk of SSI can be reduced through several factors. The National Institute for Health and Clinical Excellence (NICE) recommends that patients should be informed against removing hair from the surgical site and that patients should shower preoperatively to reduce the bacterial population.¹⁸ It is recommended to remove hair with electric clippers with disposable cartridges instead of a razor, because the use of razors may increase infection risk. However, hair removal should be performed when necessary, ideally with scissors.²⁴

Cleaning the surgical site before the procedure can be achieved with povidone–iodine, chlorhexidine, or other surgical scrubs. Appropriately prepped surgical sites have a lower rate of infection, though as 20% of skin bacteria reside deep in sebaceous glands and hair follicles, it is not possible to create an entirely sterile field by topical preparation alone.¹⁸ Still, surgical procedures on prepped skin result in a lower rate of bacteremia than brushing teeth.⁵ Surgical duration should be minimized, as prolonged operating time increases the risk that bacteria may be introduced into the wound. Hands should also be washed prior to the procedure with either alcohol-based hand rubs or aqueous scrubs such as chlorhexidine.²⁵ Current evidence suggests no difference between alcohol-based rubs with active ingredients and aqueous scrubs such as chlorhexidine in the prevention of SSIs, though chlorhexidine-based aqueous scrubs are more effective than povidone–iodine in reducing the number of bacterial colony-forming units on the hands.²⁵

In dermatologic surgery, many procedures do not require true sterile technique, and the majority of studies have not shown any statistically significant difference in infection rate when using nonsterile gloves.^{26–28} Low-cost infection protocols that eliminate the use of sterile gloves during the Mohs procedures, sterile gowns, and sterile half-sheet drapes can be implemented without negatively affecting infection risk.²⁷ Moreover, local

anesthesia itself is bacteriostatic and fungistatic, helping prevent bacterial growth.

Use of prophylactic antibiotics

Use of antibiotics should consider both the putative benefits of antibiotic prophylaxis and the risks and costs associated with the antibiotic use. Except for select circumstances, dermatologic surgery does not require prophylactic antibiotic use. In Mohs surgery, lack of antibiotic prophylaxis does not increase the infection rate.⁴

Goals of antibiotic prophylaxis

The goal of antibiotics is to reduce the risk of SSI, hematogenous joint infections, and infective endocarditis. The mechanism of infection is generally hematogenous dissemination and the development of true bacteremia; the overall incidence of postoperative bacteremia in an immunocompetent and noninfected skin site is below 1%.²⁹ Antibiotics may decrease the quantity of skin bacteria, but infection risk depends on additional bacterial characteristics such as virulence.³⁰ Importantly, the latest guidelines continue to narrow the range of patients appropriate for prophylactic antibiotics. It is important for dermatologic surgeons be aware of new guidelines to avoid the risks of antibiotic overuse and to reserve prophylactic antibiotics for patients deriving maximal benefit.³¹

Risks and costs of prophylactic antibiotics

The costs of antibiotic use include adverse events, drug interactions, financial burden, and societal costs. It is estimated that more than 140,000 visits to the emergency room are attributed to adverse effects of antibiotics annually in the United States, largely from allergic reactions to penicillin and cephalosporins.³²

Drug–drug interactions are a significant concern, as many antibiotics in common use can interact with other medications. For example, certain antibiotics can slightly increase the risk of super-therapeutic warfarin

levels³³ or the risk of hypoglycemia in diabetic patients taking sulfonylurea medications.³⁴ Indeed, clarithromycin, levofloxacin, TMP-SMX, metronidazole, and ciprofloxacin are associated with higher risk of hypoglycemia compared with noninteracting antimicrobials, with an odds ratio between 2 and 4 in older female adults.³⁴ Overall, sulfonamides and clindamycin show the highest rates of emergency room visits per number of outpatient prescriptions, averaging 1 ED visit per 500 prescriptions.³² As antibiotics adversely affect native bacterial flora, prolonged antibiotic treatment increases the risk of acquired antimicrobial resistance.³⁵ As such, unnecessary use of antibiotics contributes to worsening antibiotic resistance.²⁴ Financial costs of antibiotics include the monetary cost for the patient, the cost for treating adverse effects, and the opportunity cost of purchasing and taking the antibiotic.

Antibiotic prophylaxis for infective endocarditis

Antibiotic prophylaxis reduces the risk of infectious endocarditis in patients with high-risk surgical sites or in procedures that involve the mucous membranes such as gingival tissue or oral mucosa.³⁶ Reasons for prophylaxis for infective endocarditis include patient factors such as prosthetic cardiac valves, history of infective endocarditis, cardiac transplant with valvulopathy, patients with cardiac valve repair with recent prosthetic materials or devices, and unrepaired or residual defect after repair of congenital heart disease (Table 7-5).^{11,37} Recent prosthetic repairs consist of repaired defects using prosthetic materials during the first 6 months postoperatively, before the prosthetic material is likely endothelialized.³⁷ Importantly the high-risk category excludes patients with cardiac pacemakers and internal defibrillators, and prophylaxis is not recommended simply due to increased lifetime risk of developing infective endocarditis.³⁸

Table 7-5. High-Risk Patient Characteristics for Infective Endocarditis and Joint Infection

High Risk for Infective Endocarditis

Prosthetic cardiac valves

Hx of infective endocarditis

Cardiac transplant patients with valvulopathy

Patients with cardiac valve repairs with prosthetic materials or device in the past 5 months

Unrepaired congenital heart defect

Repaired congenital heart defect with residual defect

High Risk of Hematogenous Joint Infection

Joint replacement within 2 years of surgery

Hx of prosthetic joint infection, hemophilia, diabetes mellitus, HIV, malignancy, malnutrition, immunosuppression

Immunosuppression with RA, SLE, or drug or radiation-induced

Data from Rossi AM, Mariwalla K. Prophylactic and empiric use of antibiotics in dermatologic surgery: A review of the literature and practical consideration, *Dermatol Surg*. 2012 Dec;38(12):1898–1921.

A Dermatologic Surgery Advisory Statement recommends antibiotic prophylaxis for prevention for infective endocarditis and joint infection only if the procedure occurs on an oral site or site of active skin infection. Any patients fitting these criteria must also satisfy high-risk criteria or have a prosthetic device as defined by the American Heart Association (AHA), American Dental Association (ADA), or American Academy of Orthopedic Surgeons.

Antibiotic prophylaxis for prosthetic joints

The ADA recommends no prophylactic antibiotics prior to surgery for patients with prosthetic joints.³⁹ Previously, patients were considered high risk for hematogenous joint infection if they underwent joint replacement within 2 years of surgery, had immunosuppression or autoimmune disease such as rheumatoid arthritis or systemic lupus erythematosus, or a history of prosthetic joint infection (Table 7-5).^{11,40} In addition, previous guidelines

indicated the need for prophylaxis when the mucosa are penetrated. However, a thorough evaluation of the literature failed to demonstrate a clinically significant association between dental procedures and prosthetic joint infection in terms of effectiveness of antibiotic prophylaxis.³⁹ While the risks of antibiotics seem to outweigh their clinically significant benefits, these identified risk factors should be taken into account, along with physician judgment and patient preferences, to determine appropriate therapy.

Antibiotic selection

Antibiotics should be chosen based on the likely causative pathogens, by considering local skin flora, and keeping in mind patient-specific needs such as allergies and the ability to tolerate oral medications. Wound culture and sensitivities often drive the final selection of the antibiotics. Benefits of antibiotics are weighed carefully against the risks of use. Antibiotics tend to be reserved for specific anatomic sites, complex procedures, and immunocompromised patients.

Skin flora

Skin is colonized by many bacteria, which may vary by anatomical location (Table 7-6).¹¹ Mucous membranes tend to be colonized by *E. coli*, *Streptococcus viridans*, and *Peptostreptococci*. Intertriginous areas are often moist and macerated, predisposing to the growth of *S. aureus* and *Streptococci*. In diabetic patients, streptococcal and coliform bacteria can be found in the perioral area, ear, perineum, and anatomical sites below the waist.

Table 7-6. Bacteria Present in Normal Skin Flora in Various Anatomical Locations

Location	Normal Skin Flora	Pathogenic Bacteria
Glabrous	<i>S. aureus</i> , <i>S. saprophyticus</i> , <i>S. epidermis</i>	<i>S. aureus</i> ^a , <i>S. pyogenes</i> , <i>S. epidermis</i>
Oral or nasal mucosa	<i>S. aureus</i> , <i>Streptococci lactobacilli</i> , <i>corynebacteria</i> , anaerobes	<i>S. viridans</i> , anaerobes (<i>Peptostreptococcus</i>)
Intertriginous	<i>Corynebacterium minutissimum</i> , <i>C. lipophilicus</i> , <i>C. xerosis</i> , <i>C. jeikeium</i> , <i>Acinetobacter</i> spp., <i>S. aureus</i>	<i>S. aureus</i> ^a , <i>E. coli</i> , <i>Enterococcus</i> , <i>Bacteroides</i> , <i>Pseudomonas aeruginosa</i> , <i>Corynebacterium</i> , <i>Candida</i> , <i>Serratia</i>
Sebaceous glands and follicles	<i>Propionibacterium acnes</i> , <i>P. granulosum</i> , <i>P. avidum</i> , <i>Malassezia</i>	<i>S. aureus</i> , <i>Streptococcus</i> , anaerobic bacteria, <i>Pseudomonas</i> , gram-negative species

^a*S. aureus* may be found as a natural resident of the skin.

Adapted with permission from Rossi AM, Mariwalla K: Prophylactic and empiric use of antibiotics in dermatologic surgery: a review of the literature and practical considerations, *Dermatol Surg.* 2012 Dec;38(12):1898–1921.

S. aureus has become increasingly important in terms of both causing severe SSIs and increasing intractability to antibiotic treatment. *S. aureus* is commonly found in the mucosa, including the nasal mucosa (a common colonizing location), oropharynx, and anogenital area.⁴¹ *S. aureus* resistance has become more common, and in severe cases may be associated with mortality rates up to 20%. While MRSA had been separated into those related to health care (HC-MRSA) and community acquired (CA-MRSA), distinctions between HC-MRSA and CA-MRSA are currently much less clinically relevant as the evolution of the bacterial species has led to the loss of epidemiologic distinction.⁴¹ The CA-MRSA clones have been increasingly found in hospital and healthcare facilities⁴² leading to increased concern for healthcare providers, as these highly virulent strains can infect otherwise healthy people.⁴³

Other skin flora include nonbacterial causes such as *Candida* and less common fungal species such as *Cryptococcus*, *Aspergillus*, and *Mucor*, particularly in the immunosuppressed and immunocompromised population. Patients with inflammatory skin conditions such as atopic dermatitis carry different bacterial strains. Prolonged antibiotic use may change local skin flora, just as vancomycin can disturb the natural gastrointestinal flora which secrete antimicrobial peptides and indirectly facilitate the colonization of opportunistic pathogens.⁴⁴ Moreover, low-virulence *Streptococci* are a concern for infectious endocarditis, and *S. aureus* and *S. epidermidis* are a concern for prosthetic joint infections.

With the increased prevalence of antibiotic resistance exemplified by *S. aureus* and the slow development of new antibiotics, it is important to follow strict guidelines to prevent worsening resistance.⁴¹

ANTIBIOTIC SELECTION

In regard to the selection of antibiotics, guidelines are generally derived from the internal medicine and surgery literature, as there are few randomized double-blind studies for antibiotics in dermatologic surgery.¹¹ The choice of antibiotic use in dermatologic surgery is shown in Table 7-7. Cephalexin and dicloxacillin are systemic agents used for prophylaxis on nonmucosal surfaces to cover gram-positive and gram-negative bacteria. Per AHA guideline, *S. viridans* and *Peptostreptococci* can be treated with amoxicillin. For perineal skin, amoxicillin-clavulanate can be selected to combat potential penicillin-resistant organisms. For *Pseudomonas*, fluoroquinolones such as ciprofloxacin can be used. If a culture is obtainable, antibiotics can be selected based on antibiotic sensitivities. Otherwise, antibiotic use can be tailored to the bacteria most commonly found in the local population, the patient risk factors, the surgical site risk factors, and the surgical risk factors.

Table 7-7. Choice of Antibiotics for Prophylaxis in Patients at Risk of Surgical Site Infection

Surgical site	Antibiotic (adult dose)			
	No allergy	Penicillin allergy	Unable to take PO	Unable to take PO with penicillin allergy
Wedge excision of lip or ear, flaps on nose, grafts	Cephalexin or dicloxacillin (2 g PO)	Clindamycin (600 mg PO) or azithromycin/clarithromycin (500 mg PO)	Cefazolin/ceftriaxone (1 g IM/IV)	Clindamycin (600 mg IM/IV)
Groin or lower extremities	Cephalexin or TMP-SMX (2 g PO, double strength) or levofloxacin (1 tablet PO)	TMP-SMX (1 tablet PO, double strength) or levofloxacin (500 mg PO)	Ceftriaxone (1–2 mg IV)	Clindamycin and gentamicin (600 mg/2 mg/ kg IV)

Data from Lee MR, Paver R. Prophylactic antibiotics in dermatological surgery. *Australas J Dermatol*. 2016;57(2):83–91; Wright TI, Baddour LM, Berbari EF, et al. Antibiotic prophylaxis in dermatologic surgery: advisory statement 2008. *J Am Acad Dermatol*. 2008;59(3):464–473.

An Advisory Statement has recommended antibiotic therapy based on the procedure type and anatomical location as well as patient allergies to penicillin or inability to tolerate oral antibiotics (Table 7-7).³⁶ Cephalexin or dicloxacillin can be used as prophylaxis for wedge excisions of the lip or ear, flaps on the nose, and grafts. For those with penicillin allergy, clindamycin or azithromycin can be used, and TMP-SMX or levofloxacin may be used for anatomical sites in the groin or lower extremities. For patients who are unable to tolerate oral antibiotics, parenteral antibiotic therapy can be used. Lastly, for patients who are unable to tolerate oral antibiotics and who have a penicillin allergy, clindamycin can be used and

gentamicin added to cover for the possibility of *P. aeruginosa* infection in the groin or lower extremities.³⁶

Antibiotics are typically given the hour before the procedure. It is thought that this time permits the antibiotic to travel to the surgical site. Parenteral antibiotics are typically given half an hour preprocedure. However, there is ambiguous data about whether prophylactic antibiotic timing affects the risk of SSI.⁴⁵ For longer procedures, the desired duration of action of the antibiotic should be considered. Blood can neutralize some antiseptics as well. For carriers of *S. aureus*, transient decolonization of *S. aureus* from the nasal area can significantly reduce the infection rate, and the use of topical mupirocin–chlorhexidine reduces the infection rate by half.^{24,46}

For SSI, wound culture, microscopy, and antibiotic sensitivities should ideally be performed, and antibiotics should be tailored based on the sensitivities.

Topical antibiotics

Postoperative topical antibiotics are not recommended for routine dermatologic surgery cases.⁴⁷ Numerous studies have evaluated whether the use of topical antibiotic ointment in the postoperative period is associated with a reduction in the already very low baseline risk of SSI in dermatologic surgery procedures, and results have generally suggested that for the majority of wounds, the use of topical antibiotics does not confer a significant advantage. A wide range of topical antibiotic preparations have been explored, including fusidic acid,⁴⁸ gentamicin,⁴⁹ mupirocin,⁵⁰ tobramycin–dexamethasone (combination preparation),⁵¹ bacitracin,^{52–54} neomycin–polymyxin (and in combination),⁵³ and chloramphenicol.⁵⁵ No rigorous study has demonstrated a robust statistically significant benefit to utilizing any single topical antibiotic preparation, and the American Academy of Dermatology has, therefore, warned against the routine use of topical antibiotics after clean surgical procedures as part of its Choosing Wisely campaign.

The use of topical antibiotics may confer a risk to patients as well, since neomycin (11%) and bacitracin (8%) are the two most common causes of allergic contact dermatitis in a general patch-tested US population.⁵⁰

Inflammation risk may similarly be higher in patients treated with topical antibiotics rather than petrolatum.⁵⁶

While the routine use of topical antibiotics is inadvisable, selected surgical sites at increased risk of infection may benefit from the use of topical antibiotic therapy. One study examining the infection rate in a tropical Australian region found that a single dose of topical chloramphenicol (a topical antibiotic rarely used in the United States but popular in the United Kingdom and elsewhere) resulted in a statistically significant reduction in wound infection rate.⁵⁵ That study, however, evaluated wounds that were treated by general practitioners in Australia with a baseline infection rate in the control group of 11%, surgical sites that were possibly prepped with normal saline, and wounds that were closed with a single layer of nonabsorbable sutures; therefore, the generalizability of these findings to the generally low-risk dermatologic surgery population is unknown.

While there is little evidence to support the practice, many dermatologic surgeons—while eschewing the blanket use of topical antibiotic ointment in all surgical cases—will use these agents on select high-risk cases. Thus, wounds on the ears, nose, genitalia, lower extremities, and some flaps may benefit from the use of topical antibiotic preparations. In the United States, mupirocin is generally favored for its broad coverage and lack of significant risk of contact dermatitis. The effect on wound care compliance of providing patients with a prescription topical ointment has not been explored, though this may arguably represent an additional benefit of topical antibiotic use in select cases. As noted above, intranasal topical mupirocin may be useful preoperatively in order to temporarily decrease the nasal carriage of staphylococcal species.

Intrainscisional antibiotics

Local injection of antibiotic formulations in the perioperative period has been investigated for dermatologic surgery. While local injection of aminoglycosides may be helpful to reduce the infection risk on open fractures,⁵⁷ one challenge in dermatologic surgery remains the vanishingly low baseline rate of SSI, making any effect challenging to detect in a clinical trial setting.

One study demonstrated a statistically significant benefit to local intraincisional clindamycin injection for Mohs micrographic surgery cases.⁵⁸ This work was follow-up to an earlier report on the use of intraincisional nafcillin.⁵⁹ The solution for intraincisional clindamycin use was prepared by adding 0.15 mL of clindamycin (150 mg/mL) to a 50-cc bottle containing lidocaine (1%) with epinephrine (1:100,000) buffered with sodium bicarbonate (5 mL of an 8.4% solution). The authors noted that the solution retained its bactericidal properties for at least 1 month after preparation; given the low cost of clindamycin, it has been advocated as a reasonable approach in select patients and wounds. While this approach is not used broadly for all surgical cases, it may be a useful adjunct for wounds or patients at elevated risk of developing SSI.

CONCLUSIONS

Antibiotic use is a critical part of dermatologic surgery, though *appropriate* antibiotic use remains a significant challenge facing surgeons and patients. Given the low baseline SSI risk for most dermatologic surgery procedures, antibiotics—whether oral, topical, or intraincisional—are not routinely prescribed. For higher-risk surgical sites or patients with significant risk factors, however, antibiotics may play an important role in decreasing an elevated infection risk. In cases of active infection, antibiotic use, ideally guided by culture and sensitivity results, is warranted. All true abscesses, while rare, require drainage in addition to antibiotic treatment.

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CHAPTER 8 Photography and Digital Technology in Dermatologic Surgery

Jonathan Kantor



SUMMARY

- Three fundamental physical principles govern photography: aperture size, shutter speed, and film speed (ISO).
- Framing and composition are critical aspects of photography; traditional approaches to photographic composition, such as the rule of 3's, do not apply to most photography for surgical dermatology where the area of interest is generally centered in the frame.

Beginner Pearls



- Camera choice should not be dictated by the number of advertised megapixels.
- Lens type and lighting have a far greater impact on photograph quality than resolution.
- Archiving and organizing photographs is an important component of digital photography, and developing a systematic approach to both image capture and storage ultimately results in a more productive and professional environment.

Expert Pearls



- Recent ISDIS recommendations included lighting type (broad spectrum, even illumination, possibly tangential) background color (solid, blue or black colors preferred), field of view (centering the target), orientation, focus/depth of field, resolution (to include hair follicles on regional images and skin texture on close-up images), scale (there some debate regarding whether this is of value), and image storage quality.
- Instead of using specialized photographic equipment, standalone LED worklights may be purchased at a home improvement store.

Don't Forget!



- All images should be saved at the highest-quality setting available on the device.
- Head- or body-mounted video recording devices are very sensitive to slight body movement by the surgeon and may introduce significant camera shake, which is undesirable.

Pitfalls and Cautions



- Ideally, data should be stored on an encrypted drive. Encryption options are built-in to both Apple (using Filevault) and Windows (using Bitlocker) computers.
- All photographs should be taken from the same angle and should include the same amount of surrounding skin in the field; this allows the viewer to see only the surgical procedure as the rest of the image is held constant.

Patient Education Points



- Dermatologic surgeons involved in education and publishing may wish to have all patients sign a blanket photography consent and release so that there is no question after the fact regarding whether individual images can be used.
- When possible, identifying information should not be captured in a photograph unless doing so is necessary.
- Patients may be reassured that all images will be stored in an encrypted format.
- A separate social media release may be helpful if images are to be shared publicly.

CHAPTER 8 Photography and Digital Technology in Dermatologic Surgery

INTRODUCTION

Dermatologic surgery is a visual field. Preserving a visual rendition of a particular disease entity, biopsy site, surgical technique, or surgical outcome is a critical part of the dermatologic surgeon's practice.

The advent of the printing press in 15th-century Europe changed the medical landscape, as the written word could efficiently and (relatively) inexpensively be transmitted to others around the world.

Nineteenth-century dermatology texts, such as Robert Willan's *On Cutaneous Diseases*, and Pierre Louis Alphonse Cazenave's *Maladies de la Peau* relied on hand-drawn color plates to convey the subtleties of clinical conditions.

Moulage, the three-dimensional (3-D) wax models designed to convey—in sometimes haunting detail—the appearance of particular skin diseases, were frequently used in teaching centers of 19th-century France and later around the world.¹ In the late 19th and early 20th centuries, stereoscopic cards came into vogue and were used widely for dermatologic education, particularly for explaining basic skin conditions to generalist physicians.²

The advent of low-cost photography led to a sea change in dermatologic education, as the democratization of dermatologic education increased at a logarithmic rate. Indeed, it was no longer necessary to study with a master

clinician or in a major center to be exposed to a wide array of skin diseases, since every budding dermatologist could be exposed to accurate high-fidelity images of a variety of diseases of the skin.

In dermatologic surgery, a similar transition took place over the latter part of the 20th century, as photography—and, more recently, videography—permitted the sharing of information, techniques, and approaches around the world. Indeed, the rise of dermatologic surgery as field can in some ways be seen as the product of the democratization of closely held techniques.

PHOTOGRAPHY

For practical purposes, all photography in dermatologic surgery today is digital photography; while film photography may be used on occasion; this is generally done for artistic, rather than practical, purposes.

Fundamentals of photography

While most dermatologic surgeons can easily accomplish all skin photography with a simple point-and-shoot camera—or even a smartphone camera—a basic understanding of the principles of photography remains helpful.

Three fundamental physical principles govern photography: aperture size, shutter speed, and film speed (ISO). The interplay between these physical components of a photograph has the potential to significantly affect the quality and value of a photograph (Fig. 8-1).

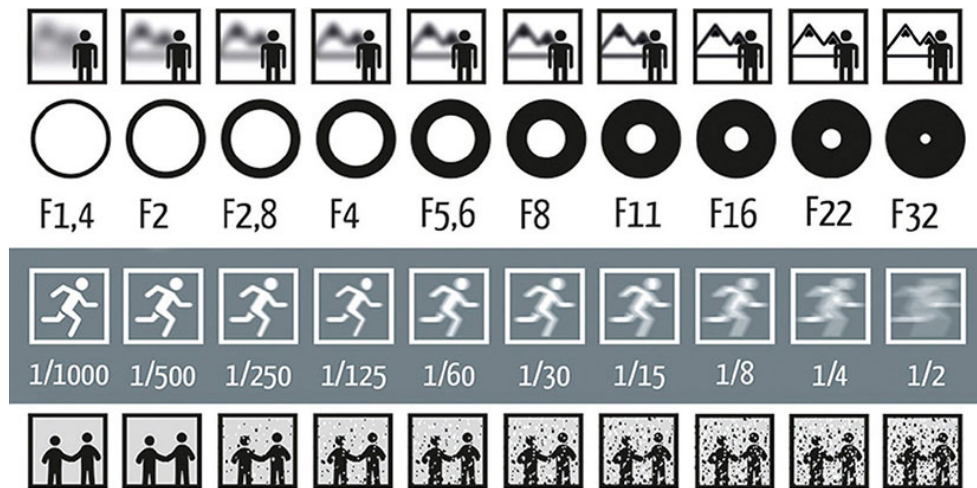


Figure 8-1. The relationship between aperture (**top row**), shutter speed (**middle row**), and film speed/ISO (**bottom row**). Note that with larger apertures (smaller f-stops) there is a markedly reduced depth of field.

The aperture is a measure of the size of the opening that allows light to enter the camera and come into contact with the CCD array, and is inversely related to the f-stop number. There is a tradeoff between aperture size and depth of field; larger apertures (smaller f-stop numbers) permit more light to enter the lens, and thus permit a faster shutter speed and crisper image. This also results in a shallower depth of field, where only portions of an image may appear to be in focus. This is a particular problem when taking macro photographs of structures with significant 3-D variability, such as the nose. The use of a powerful and consistent flash, as well as a steady hand or tripod, may partially make up for this tradeoff and permits smaller aperture sizes for these images.

Framing and composition are critical aspects of photography; traditional approaches to photographic composition, such as the rule of 3s, do not apply to most photography for surgical dermatology where the area of interest is generally centered in the frame.

White balance is usually performed automatically with most modern cameras; for most applications in dermatologic surgery, this is more than adequate.

Most dermatologic surgeons use an automatic focus setting, whether on a point-and-shoot or single-lens reflex camera. Manual focus options allow increased control, but concomitantly introduce a significant potential for operator error. Many cameras offer several options for automatic focus;

since dermatologic surgery photography usually relies on a centered image of interest, autofocus using a central point may work best for this application.

Standardization

The Digital Imaging and Communications in Medicine (DICOM) standards are used for specialized medical imaging such as that performed by radiologists. In dermatology, given the wide availability of consumer-level imaging equipment, the DICOM standards are typically not used.³ Recently, the International Society for Digital Imaging of the Skin (ISDIS) proposed a new set of standards for dermatology imaging that address many of quality and generalizability concerns regarding skin photographs.³ These should be understood within the context of similar proposals by a number of other potential stakeholders, such as the American Telemedicine Association.

The recent recommendations included a discussion of lighting type (broad spectrum, even illumination, possibly tangential) background color (solid, blue or black colors preferred), field of view (centering the target), orientation, focus/depth of field, resolution (to include hair follicles on regional images and skin texture on close-up images), scale (there some debate regarding whether this is of value), and image storage quality.³

Camera selection

With quality improvements in smartphone and tablet cameras, almost all dermatologic surgery images today can be adequately captured on simple point-and-shoot, smartphone, or tablet cameras. For dermatologic surgeons who plan to publish photographs or perform clinical studies, D-SLR (digital single-lens reflex) cameras with interchangeable lenses and a dedicated flash system may be helpful.

The resolution available in even smartphone cameras exceeds that needed for almost any application in dermatologic surgery. Therefore, camera choice should not be dictated by the number of advertised megapixels.

D-SLR cameras are often chosen not because of their resolution, but because they have the ability to work with a range of lens types and flash systems. Ultimately, lens type and lighting have a far greater impact on photograph quality than resolution. Therefore, all else being equal, a D-SLR

with a 5-megapixel resolution is far superior to a point-and-shoot camera with a 25-megapixel resolution.

A 60-mm or 100-mm macro lens is helpful for close-up photography, and may be used for standardized photographs. Classically, dermatologic surgeons have advocated using sidelighting. An LED ring flash, however, is very effective at standardizing lighting between photographs. Since dermatologic surgery photographs benefit from overall high-quality lighting, rather than the focus on skin texture that is important when recording medical dermatology photographs, a ring flash is often very useful.

All-in-one photographic systems are available from several manufacturers, although their adoption is limited by their significant cost and marginal improvement over using standardized poses and equipment; thus, their use is largely limited to clinical trials and some academic centers.

File sizes and formats

Even the best photographer composing ideal images with an outstanding camera will not be able to convey quality images if they are not saving their files appropriately. Smartphone, tablet, and point-and-shoot cameras are all able to record at a range of quality settings. As a general rule, all images should be saved at the highest-quality setting available on the device, as images can always be compressed at a later date if needed. Taking a few moments to set up the camera appropriately with the highest-quality settings is an excellent time investment.

For D-SLRs, additional options are often available. Most cameras permit the user to save files in RAW format (the highest quality available) as well as one of many compressed formats. One useful approach is to set the D-SLR to record *both* RAW and highest-quality (largest) JPEG (or other compressed) formats; if significant adjustment will not be needed, the JPEG images can be used for almost every application, while the RAW images can be manipulated if needed without impacting file quality.

Occasionally, reference is made to the distinction between *lossless* and *lossy* compression. The former allows digital images to be compressed but (as the name implies) does not result in any loss of image data (e.g., TIFF). The latter leads to much more dramatic compression—and hence smaller file sizes—but also results in a decrease in data included in the image (e.g.,

JPEG). That said, for all practical purposes most JPEG images are more than adequate for any application in dermatologic surgery.

For video, many smartphones now record at 4K resolution, far higher than can be appreciated except on the largest screens—or unless single frames are teased out or images are significantly zoomed. Therefore, resolution is no longer the quality-limiting step in video recording. By definition, the smaller lenses on smartphones have only a fraction of the light-capturing ability of large D-SLR cameras or dedicated video equipment, though with appropriate lighting and stabilization, as well as simple postproduction quality improvement, they can provide quality rivaling that seen using professional-grade equipment.

Video should be recorded in a standard format and retained at the highest-quality setting available. The cost of digital storage continues to plummet, and quality video should never be compromised simply to save storage space.

When preparing to publish photographs in print, the number of dots per inch (DPI) is often used as a measure of quality. As a general rule, high-gloss print publication should use images that are saved at 300 DPI; this is far greater than the 72 DPI that is standard for on-screen presentation. Of course, the number of DPI must be interpreted in concert with the overall size of the image—the number of pixels that are included horizontally and vertically.

HIPAA compliance

The Health Insurance Portability and Accountability Act (HIPAA) defines personal health information (PHI) as “individually identifiable health information transmitted or maintained” by any covered entity. Thus identifiable photographs fall under this rubric, assuming that they can be reasonably connected to the person in question. Full-face photographs certainly fall under this definition, and many photographs with minimal editing, such as the black bars over the eyes that were once popular for de-identification, also may remain identifiable. Moreover, other features, such as unique or identifying tattoos, may raise the specter of HIPAA protection even if no facial features are present.

It is always best to err on the side of caution regarding de-identification and compliance; thus, when possible and feasible, partial-face photos, rather

than full-face photos, may be used.

Most importantly, however, patient consent for recording their identifying photographs as well as potential uses for the photographs should always be sought. In practice, active dermatologic surgeons involved in education and publishing may wish to have all patients sign a blanket photography consent and release so that there is no question after the fact regarding whether individual images can be used. It is often easier to explain to all patients that their photos may be used; for those few patients who refuse (generally a small minority), their charts can easily be flagged to ensure that photographs are not taken.

Ideally, data should be stored on an encrypted drive. Encryption options are built-in to both Apple (using Filevault) and Windows (using Bitlocker) computers. Removable media, such as external hard drives or USB sticks, may also be easily encrypted using built-in software. Encryption is particularly valuable for laptops, as a stolen laptop with PHI may represent a significant security breach. If the laptop is encrypted, however, the data remain secure and no HIPAA violation will have occurred. One recent study has addressed the marked variability in approaches by Mohs surgeons to storing digital photographs.⁴

Video capture

Video is a useful adjunct for patient education, and is also helpful when teaching residents, students, and colleagues. Several simple steps may be helpful when attempting to capture effective video.

First, as with still photographs, minimize distractions within the frame; the video and audio should include any necessary features being conveyed while excluding distracting background. For example, video of a surgical procedure should include the entire surgical site from either the surgeon's perspective or directly overhead, ideally with a small margin of blue or green drape around the periphery. Even for practices that generally rely on disposable fenestrated drapes for surgical procedures, it may be worthwhile to use cloth drapes for recorded surgical procedures given the overall aesthetic improvement.

Second, audio voiceovers may be useful, particularly when the goal of the video is largely didactic. This can be accomplished either from directly

within freely available video editing software or using specialized audio editing software. A USB-based condenser microphone may be a good investment if significant audio recording is anticipated.

Third, lighting is probably the greatest contributor to video quality; surgical video recording can be performed ideally using a set of two white light LED arrays. Instead of using specialized photographic equipment, standalone LED worklights may be purchased at a home improvement store. Avoid using head-mounted LEDs, as these create a small bright focus of light that may wash out the remainder of the image.

Fourth, video recording is dependent on the steadiness of the camera. In general, a tripod works well, and for overhead video recording a perpendicular arm may be added (and is included with some tripods) for better stabilization and a bird's eye view of the procedure.

Head- or body-mounted video recording devices are popular in action sports and are used by some dermatologic surgeons. The disadvantage of these approaches is that the mounts are very sensitive to slight body movement by the surgeon and may introduce significant camera shake, which is undesirable.

Approaches to skin photography

Facial photography

Standardized poses are very useful in photography for dermatologic surgery. For facial procedures, a set of three photographs is often sufficient: the anterior–posterior view, oblique view, and lateral view ([Fig. 8-2](#)). For nasal reconstruction, a base view may be helpful as well to assess alar asymmetry.⁵



AP View:

- Align pupils and top of ears
- Make sure you can see base of nostrils



Lateral View:

- Align lateral canthus and top of ear
- Align brow ridge and chin
- Should not see the contralateral brow or philtrum



Oblique View:

- Align pupils and top of ears
- Tip of nose should line up with the zygomatic arch on the contralateral side

Figure 8-2. A photography guidelines sheet for use in the office setting. (Based on Martinez JC. Standardized photography in facial reconstructive surgery: clinical pearls to simplify a complicated task, *Dermatol Surg.* 2011 Jan;37(1):82–85).

Capturing images using standard poses permits better before-and-after comparisons and more meaningful and intuitive photographs.

For all photographs, patients should be looking straight ahead with a neutral expression. A plain-colored background is ideal, and this can be easily accomplished with either a colored backdrop placed on the back of each examination room door or the use of a neutral paint color on the examination room walls.

Body photography

For photographs of the trunk and extremities, standardized angles and poses have been proposed by the American Society for Dermatologic Surgery. These are most useful for cosmetic procedures, when documenting the degree of improvement seen after an interventional procedure is useful. The regional photographs can also be used for surgical site photography, though the images may need to be zoomed in significantly to be meaningful.

Surgical site photography

For surgical procedure on the head and neck, standardized poses may be useful for recording outcomes and evolution over time. Some surgical procedures may also benefit from close-up photographs of the surgical site, in which case variations of the standardized poses may be recorded. Alternatively, if high-resolution imaging is used, photographs may be zoomed and cropped after the fact.

Next to a well-composed high-resolution photograph with minimal distractions, the next most important priority for surgical site photography is consistent angle and perspective. All photographs should be taken from the same angle and should include the same amount of surrounding skin in the field; this allows the viewer to see only the surgical procedure as the change as the rest of the image is held constant.

For educational purposes, step-by-step photographs are often useful as well. In these cases, either an overhead or over-the-shoulder perspective is most useful, as it permits the viewer to intuitively understand the procedure and identify with the surgeon's movements.

Photography has also been used for Mohs map creation.⁶⁻⁸ Particularly for large or complex cases, the Mohs map can be overlaid on a printout of a digital photograph. This may assist with accurate map creation and is also useful in the unlikely event that a patient will need to be referred on for adjuvant treatment.⁶ Fully digital Mohs maps may be useful as well, as these do not require printing of photographs and are easily shared in an electronic medical record system (Fig. 8-3).



Figure 8-3. A fully digital Mohs map.

Photography for biopsy-site identification

Biopsy-site identification is of critical importance, as wrong-site surgery has potentially serious consequences for both patient and surgeon. Indeed, wrong-site surgery is one of the most common and serious adverse events identified by the Joint Commission,^{9–12} and one of the most common causes of medical malpractice cases against Mohs surgeons.¹³ As many as one-quarter of patients may not be able to correctly identify their biopsy site.¹⁴

Dermatologic surgeons frequently use photography to record biopsy sites. Importantly, biopsy-site photography must include sufficient local landmarks to identify the location adequately. Thus macro photographs of the lesion of interest, if taken, should be supplemented with regional photographs that are self-explanatory with respect to site identification. Ideally, biopsy-site photographs would be included in a patient's electronic medical record, though this may be limited by practical and privacy considerations. Biopsy-site photographs are particularly useful when patient and surgeon do not immediately agree on the identification of the putative biopsy site.

Recently, patient-recorded biopsy-site photography has been explored as an adjunct approach to biopsy-site identification.¹⁴ The advantage of this

approach is that it does not require any HIPAA protection or data protection on the part of the surgeon, as the patient is responsible for storing their own photographs. This is also, however, its chief pitfall, as the surgeon is then reliant on the patient to bring their images to the visit; the worst-case scenario would be a patient who fails to bring their images to the surgical appointment and verbally confirms a biopsy site, only to later revise this decision based on newly discovered photographs. Some limitations of patient-recorded biopsy-site photographs include the tendency to excessively zoom and to take photographs that are out of focus.^{9,14} An approach using a separate photographer has been suggested as a solution to some of these quality concerns.⁹ Skin self-photography may be useful for dysplastic nevus monitoring,¹⁵ though the consequences of a forgotten or lost image or set of images are potentially greater when this approach is used for biopsy-site recording. Using a standalone iPod that is encrypted and not connected to the internet is a simple solution to this common problem, as the device is inexpensive, portable, and is easy to search when a patient returns and the biopsy site must be identified. Since the same device both records and organizes the photographs, it significantly reduces the need for staff time investment.

Postoperative monitoring

The widespread use of smartphone digital cameras has led to the investigation of their use for postoperative wound monitoring.^{16,17} Studies have examined patient satisfaction associated with taking photographs and using a mobile application to communicate with the surgeon and support staff. As with chronic wound management, patients appear to be largely enthusiastic regarding the possibility of engaging in remote wound monitoring.

Telesurgery consultation

Surgical consultation may take place with the assistance of teledermatology techniques. The American Academy of Dermatology has guidelines in place regarding teledermatology consultation, and advocates that physicians establish a true physician–patient relationship prior to a teledermatology

consultation.^{18–22} Given the limitations of this approach coupled with the feasibility of same-day consultation for most Mohs surgical procedures, this is rarely needed in practice. Still, it remains a useful adjunct in the event that a patient or referring physician expresses a preference for a consultation prior to the day of surgery.

OTHER TECHNOLOGY APPLICATIONS

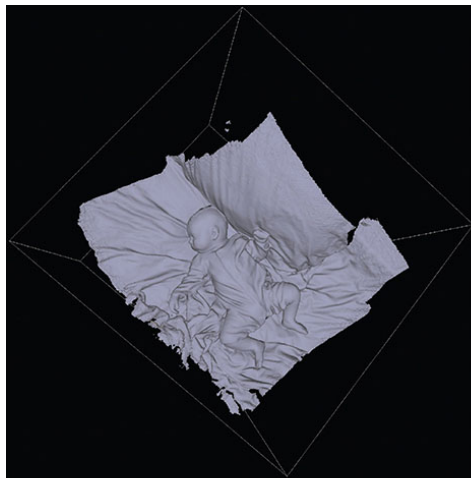
Several other technologies have been explored for use in the dermatologic surgery setting, though their adoption, at this point, has yet to become widespread. Many of these approaches are used widely for research and are in the development stage for practical daily use in the dermatologic surgery practice. Widespread adoption will depend in part on ease of use as well as financial considerations.

Reflectance confocal microscopy permits *in vivo* analysis of human skin, with resolution rivaling that of traditional histopathology. Until recently, this technology was limited by the learning curve associated with interpreting the grayscale images; over the past decade, digitally stained mosaic images have become available that mimic the colors and shapes seen with traditional histopathology.^{23–30} This represents a major step forward in potentially broadening the use of this approach, as posttraining interobserver agreement was found to be 98%. A multimodal microscopy approach has been developed using acridine orange fluorescence, eosin fluorescence, and endogenous fluorescence to image cellular nuclei, cytoplasm, and extracellular components, respectively.²³ This approach permits confocal microscopy to be used not only for basal cell carcinoma, but squamous cell carcinoma detection as well. A more rapid, and therefore potentially more clinically useful, approach has been developed using high-speed strip mosaicing confocal microscopy as well.^{30,31}

Optical coherence tomography is another *in vivo* real-time imaging technique that can be used for diagnostic purposes. As with confocal microscopy, it has been used for diagnosing basal cell carcinoma. While this technology may increase the diagnostic accuracy of a clinical examination,³² it is also imperfect, and indeed one case of amelanotic melanoma was misdiagnosed as basal cell carcinoma in an Australian study.^{33,34} Dynamic

optical coherence tomography may overcome this limitation, though further research and product development need to occur.^{35,36} Therefore, while this technology holds significant promise for the future, traditional histopathology remains the gold standard.

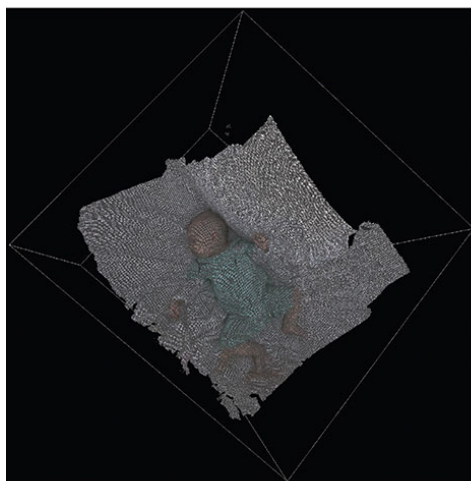
Other technological approaches that have been explored include the use of head-mounted camera and computer systems such as Google Glass,^{37,38} the use of infrared thermal imaging, and the use of 3-D imaging and cameras,³⁹ as well as 3-D scanning devices (Fig. 8-4).^{40–42} Near-infrared imaging of vascular structures is also available, though these devices are severely limited by their limited applicability to dermatologic surgery and significant upfront cost. While all of these approaches may be valuable, they have yet to be widely adopted in dermatologic surgery.



A



B



C

Figure 8-4. The next generation of three-dimensional imaging. Data may be acquired with a variety of technologies, including a structured light sensor or stereophotogrammetry in order to create a solid model (A), a colorized three-dimensional image (B), or an overlay with a three-dimensional mesh (C).

CONCLUSIONS

Photography is now an integral part of the practice of dermatologic surgery. On a practical level, training office staff to record photographs using standard poses and positions is a worthwhile effort, and results in images that are consistent and reproducible. Archiving and organizing photographs is an important component of digital photography, and developing a systematic approach to both image capture and storage ultimately results in a more productive and professional environment.

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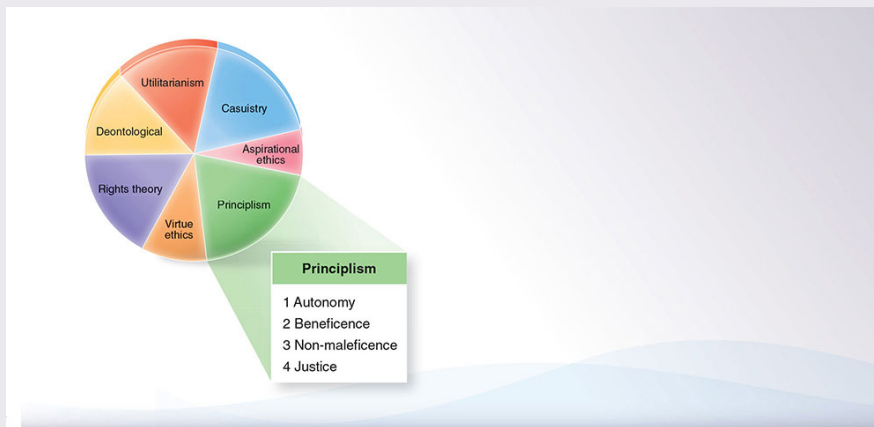
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CHAPTER 9 Ethics in Dermatologic Surgery

Jonathan Kantor



SUMMARY

- Ethical action, like informed consent, is a process.
- Most ethical challenges occur when there are conflicting principles, conflicting duties, or conflicting concepts of to whom the greatest—or least—ethical allegiance is owed.

Beginner Pearls



- For centuries, philosophers have struggled with the distinctions between ethics, morality, law, and—more recently—professionalism.
- Ethics reflects a social imperative that is based on moral underpinnings; ethics can therefore be conceptualized as morality in action.

Expert Pearls



- Professional morality may be broader and deeper than common morality, as it addresses the moral expectations for a particular group.
- Principlism, perhaps the most popular ethical framework, relies on the (equally weighted) principles of autonomy, beneficence, nonmaleficence, and justice. These four principles are frequently used as a litmus test for ethical legitimacy.
- Morality is a social institution, and the common morality represents the core group of morals that are considered universally binding.

Don't Forget!



- Other approaches to ethical decision-making abound, including utilitarianism, aspirational ethics, casuistry, deontological approaches, rights theory, and virtue ethics.
- While cosmetic dermatology patients may interact with physicians as if they are *consumers*, rather than *patients*, they should still be treated as the latter.

Pitfalls and Cautions



- Keep in mind that there is often more than one reasonable solution to an ethical quandary.
- An action can be legal without being ethical and ethical without being legal.
- Body dysmorphic disorder is a common condition, and identifying such patients is an important challenge for the cosmetic dermatologist, not least because the patient is likely to be dissatisfied after *any* intervention.
- The need for a consistent ethical framework led to the expansion of principlism to the point that the four principles are frequently used as a litmus test for ethical legitimacy, though the challenges of this model of applied ethics may be substantial.

CHAPTER 9 Ethics in Dermatologic Surgery

INTRODUCTION

Appreciating and understanding the fundamentals of bioethics is of significant importance for dermatologic surgeons, both in order to better assess and evaluate the nature of ethical challenges and to better engage in informed ethical decision making. The epistemology of bioethics—how we know what falls within the boundaries of ethical actions and what does not—is worth exploring not simply as an intellectual exercise, but as a stepping stone to expanding our understanding of *why* a particular act is or is not the appropriate choice in any given situation.

Despite a 200-year trend of codifying ethical and professional mores, the subjective nature of morality and ethics may be challenging, particularly for physicians whom, as scientists, expect an objective and standardized system rather than a relativistic amalgam of duties and principles.

Ethical challenges may be of several varieties. Sometimes, a true moral or *ethical* dilemma is present, while at others the central challenge is a *practical* dilemma, where a sense of ethical obligation conflicts with either self-interest or pragmatic considerations. Most ethical challenges occur when there are conflicting principles, conflicting duties, or conflicting concepts of to whom the greatest—or least—ethical allegiance is owed.

Ethical action, like informed consent, is a process. Indeed, the very act of expressing concern regarding the ethical implications of an action constitutes a significant step in the right direction, as even professional ethicists may disagree regarding the ideal course of action in complex ethical cases. Real-

world ethical challenges generally occur when various ethical imperatives are perceived as being in conflict, or when various duties, and those to whom the dermatologist is responsible, appear to conflict.

HISTORY

Ethics has been a subject of discussion, debate, and deliberation for thousands of years. While the nascence of ethical and moral theories is often ascribed to ancient Greek philosophers, Mesopotamian writings and codes of law—as well as ancient Greek epic poems significantly predating the development of true Greek philosophy and the Old Testament itself—address fundamental ethical issues.¹ Subsequent ancient Greek philosophical writings, particularly those of Plato and Aristotle, formally codified a system of ethical thought.²

In ancient Greece, Socrates spoke at length of fundamental principles that would today be considered utilitarian, with a focus on creating the greatest good.^{3,4} Aristotle is often considered the father of modern ethics, with his focus on eudaimonia; to Aristotle, appreciating the nature of ethics was a prerequisite to leading the ideal flourishing life.^{5–10}

The origins of bioethics as a distinct field of inquiry may be traced to the 1770 publication of John Gregory's *Lectures on the Duties and Qualifications of a Physician* and the subsequent 1803 publication of Thomas Percival's *Medical Ethics* (Fig. 9-1).^{11–14} In Percival's code—later used as a model for the American Medical Association's (AMA) first *Code of Ethics*—he reviewed the ethical underpinnings of practice and duty in an organized fashion. It is no surprise that this occurred in the context of the industrial revolution and rapid developments in the field of medicine, when medical care had shifted from a Galenic worldview to a proto-scientific approach to inquiry.¹⁵ Suddenly, the physician had a greater role to play in decisions that could reasonably have a major impact on the patient's life. Moreover, in the post-enlightenment period, the desires of the patient as an individual also took on a more important role. Further, as society evolved from a medieval feudal system to the beginnings of the modern industrialized world that we know today, obligations—between worker and employer, citizen and country, and physician and patient—took on a more urgent role.¹⁶

Finally, in the United States in the 1820s, with new world medical education still in its infancy, physicians turned to self-regulation in an attempt to staunch the pressure from charlatans who were felt to be unfairly charging and improperly treating their unwitting patients.¹

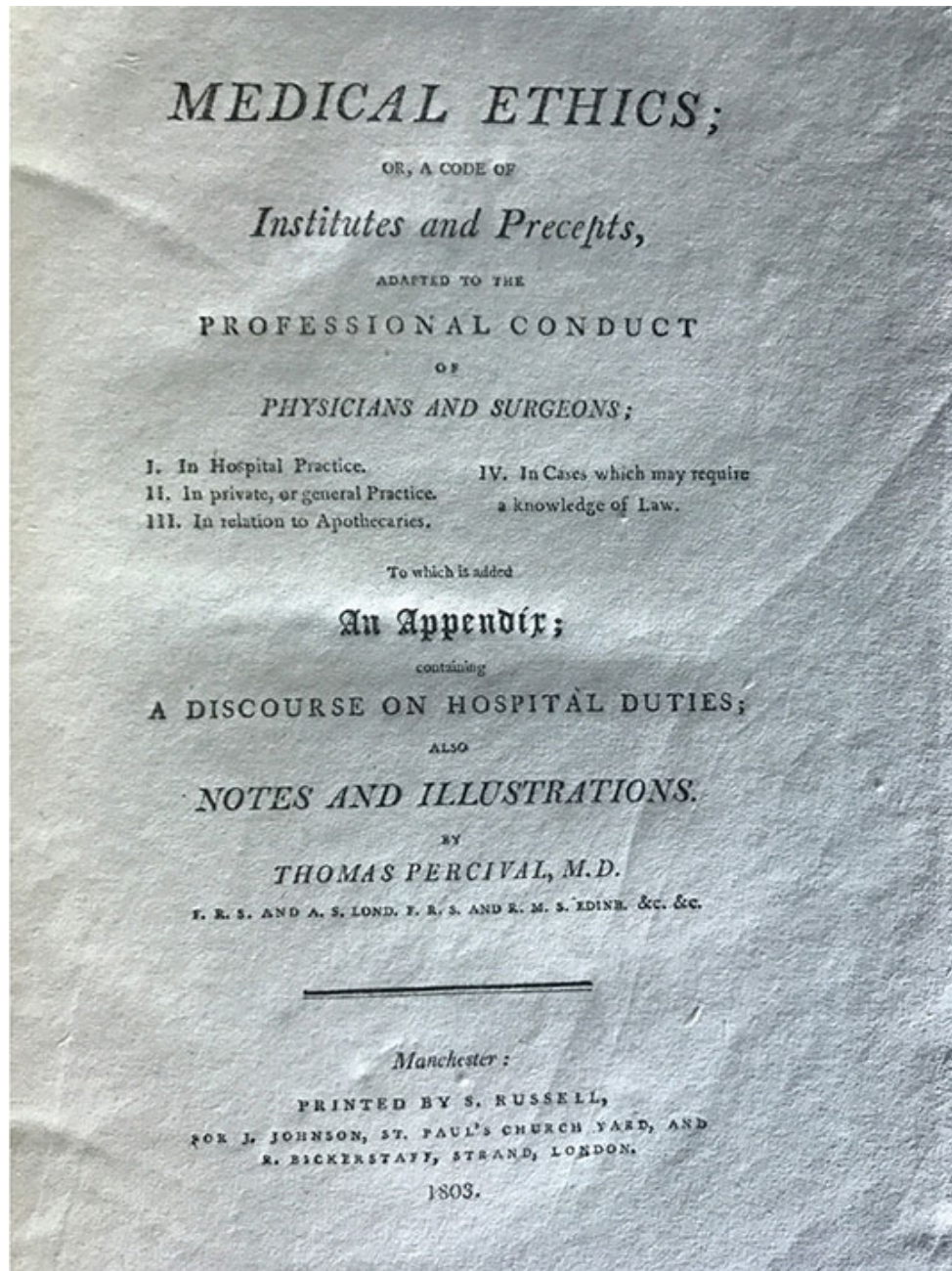


Figure 9-1. First edition of Thomas Percival's medical ethics.

Modern warfare also impacted the perceived need for a robust grounding in medical ethics. From the bloody US Civil War to the trenches of the First World War and the mass slaughter of the Second World War, the very tools of industrialization that were lauded as harbingers of a truly brave new world were used to take military and civilian lives on a previously unimaginable scale.

With this backdrop, it is no surprise that ethics in medicine took on an even greater urgency in the 20th century. From Tuskegee to Josef Mengele, physicians—long lauded as working in their patients’ best interests—were suddenly seen, as industrialization was in the centuries before, to represent a powerful force that could as easily harm as help.

Ethics, law, morality, and professionalism

For centuries, philosophers have struggled with the distinctions between ethics, morality, law, and—more recently—professionalism. Morals, or common morality, represent a set of behaviors, actions, and imperatives that are so broadly understood to be true that they have been accepted as fundamental and universal. Horace noted over 2,000 years ago that laws without morals are useless,¹⁷ and indeed while moral laws are desirable, only a fraction of moral actions are enumerated in law. Morality, therefore, is a social institution, and the common morality represents the core group of morals that are considered universally binding.

The common morality encompasses not only a set of obligations (do not kill, do not steal), but also a group of ideals and virtues (be charitable, help others when possible). These morals are universally accepted within a society, and their acceptance is often considered a precondition for entry and societal acceptance.¹⁸

Ethics reflects a social imperative that is based on moral underpinnings; ethics can therefore be conceptualized as morality in action. This is distinct from laws, which are specific rules that have attendant consequences and penalties when they are violated. A particular act may be ethical while being illegal (a woman driving alone in Saudi Arabia) or legal while being unethical (racist speech in the United States).

Professionalism, in contrast, focuses on the role of the physician as professional, and expectations that are inherent in this professional role.

Professional morality may be broader and deeper than common morality, as it addresses the moral expectations for a particular group.^{19–22} Thus the American Academy of Dermatology’s (AAD) Ethics Pledge, for example, includes a broader group of commitments than would be expected of a member of the general public.²³ Indeed, biomedical ethics has been codified repeatedly, whether in Percival’s book, the AMA’s original ethics code (first published in 1847), or the AAD’s Ethics Pledge.

Ethical frameworks

Principlism

Over the past few decades, biomedical ethics, particularly in the United States, has become largely synonymous with principlism. This ethical framework, stemming largely from the seminal Belmont Report, focuses on four principles considered when evaluating an ethical conundrum (Table 9-1).²⁴ The Belmont Report outlined the principles of respect for persons (autonomy), beneficence (and nonmaleficence), and justice. These principles have been popularized and are now so enmeshed in the modern understanding of bioethics that principlism is in many areas seen as synonymous with bioethics.

Table 9-1. Principles of Bioethics

Principle	Definition
Autonomy	Patients should be treated as autonomous agents.
Beneficence	Patients should be treated for their benefit.
Nonmaleficence	Patients should not be harmed.
Justice	There should be fairness in ethical action.

Note: All principles are weighted equally.

First, the principle of autonomy focuses on the premise that individuals should be treated as unique persons, and that their individual autonomous

choices should be respected. The corollary of this approach is that those with diminished autonomy (children, prisoners, and others) should be entitled to special protection. Second, the principle of beneficence touches on an obligation by physicians to secure the well-being of their patients. In the Belmont Report, its corollary, nonmaleficence, or *not* harming the patient, was included under a single rubric. Finally, the principle of justice touches on an underlying need for fairness.

The need for a consistent ethical framework led to the expansion of principlism to the point that the four principles are frequently used as a litmus test for ethical legitimacy. Still, the challenges of this model of applied ethics may be substantial,^{25,26} and some philosophers have argued that the very model of medical ethics appropriating philosophical doctrines is flawed.¹¹

Casuistry

The casuistic method involves the extrapolation of the circumstances of one accepted or paradigmatic case to a new circumstance in order to develop a valid ethical decision (Table 9-2).^{27–30} This approach, rooted in Talmudic and ancient Christian exegesis, is frequently applied today in the field of law. Rather than relying on potentially arbitrary principles, the casuistic approach instead turns to paradigmatic cases where the ethical course of action has either already been determined or is *prima facie* clear. While this approach is predicated on the proper determination of relevant cases,³¹ its advantage is that it is rooted in an intuitive common-sense approach to ethics.

Table 9-2. Ethical Approaches

Approach	Definition
Principlism	Four principles determine ethical action.
Casistry	Prior cases determine ethical action.
Utilitarianism	Maximizing benefits determines ethical action.
Deontological	Rules dictate ethical action.
Rights theory	Respecting the actor's rights determines ethical action.
Virtue ethics	Cultivating virtues determines ethical actions.
Aspirational ethics	Obligations (at a minimum) and supererogation (ideally) determine ethical action.

Utilitarianism

Unlike principlism, predicated on the inherent value of a set of accepted principles, utilitarianism is a consequentialist approach that aims to do the greatest good for the greatest number—to maximize utility.^{32,33} One advantage of utilitarianism is that it does not require the intellectual exercise of accepting four, and only four, principles as the bedrock of ethical action. Still, a utilitarian approach that requires the physician to dispassionately create the most good (or cause the least harm) over all else necessarily creates secondary questions, including perspective (doing the most good for whom?), paternalism (who decides on what is the most good?), and possible ethical conflicts (utilitarianism embodies the idea that the end indeed justifies the means). Other concerns regarding utilitarianism include the demandingness objection (the concept that pure utilitarianism may be too demanding to be adopted on a practical level),³⁴ and the risks of unjust distribution, as doing the greatest good for the greatest number may consistently marginalize minority groups.

Deontological approaches

Deontological, or rules-based, ethical approaches are another prism through which ethical action may be viewed.^{32,33} Kant's categorical imperative aims to simplify and codify ethical action, by stating that one should never act except in such a way that they would wish the maxim driving their actions to become universal. His approach has also been outlined as the unacceptability of treating others as a means alone. This obligation-oriented approach is fundamentally different from the utilitarian approach, where the *outcomes* of the action govern its ethical legitimacy; for the Kantian, the *motives* of the action decide on its ethical grounding.

Another deontological approach is the divine command theory—the idea that while adherence to rules and obligations indeed determine the rightness of an action, the source of such obligations is not a rational actor's decision, but divine law. Thus religiously rooted ethical frameworks represent a form of deontological ethics; the rightness and morality of an action are determined by whether it was ordered by God.

Rights theory

Rights theory, the concept that the ethics of an action is determined based on their alignment with a set of human rights, is another approach to bioethics.³⁵ The idea of moral rights (what the target of action is *owed*) differs fundamentally from the idea of moral obligation (what the actor is *obligated* to do), although in practice ethical actions often align. Since rights represent an entitlement, they may be attractive when trying to protect a group of patients. Yet since rights theory does not address the rights of the community at large, it leads to possible challenges when attempting to formulate a general framework for biomedical ethics that may be applied universally.

Virtue ethics

Unlike utilitarian and deontological approaches, virtue ethics focuses not on the obligations of an actor, but on the underlying virtues that are cultivated by individual actions.^{21,36–45} If an action cultivates virtuous traits, then it is ethical. Like Kant, an Aristotelian virtue ethics approach determines an action's value based on the *motivations* of the actor, not their actions. A virtue-ethics approach embodies the idea that character is destiny; obligation-oriented approaches that set out a minimum list of rules and

obligations do not, to the virtue ethicist, lead to better behavior. Virtuous judgments, therefore, are seen as the basis of ethical action.

Virtue ethics has been used to delineate a set of ideal virtues—the professional responsibility model—for the physician leader as well.²⁰ Such virtues include self-effacement, self-sacrifice, compassion, and integrity. Like principlism, virtue ethics may be criticized for its seemingly arbitrary selection of virtues, a shortcoming that becomes particularly apparent when disparate virtues are functionally competing.

Aspirational ethics

Aspirational ethics is a synthesis of obligation- and virtue-based approaches.^{34,46–48} Like obligation ethics, it accepts that there is a set of obligations that may be codified to set a *minimum* level of acceptable behavior. But like virtue ethics, aspirational ethics focuses on cultivating a set of actions that motivate the actor, essentially moving from the normative (what is absolutely required) to the supererogative (what would be ideal).^{34,46,47} By combining the strengths of principlism, utilitarianism, and deontological approaches (setting an ethical floor) with the ideals of virtue ethics (aiming for an ethical ceiling) and aspirational ethics both guarantees basic safeties and protections while concomitantly promoting growth and excellence.

Common issues facing the dermatologic surgeon

Patient privacy and autonomy

There is a rich literature on patient autonomy. Various manuscripts have addressed the treatment of the impaired patient, the minor patient, and the prisoner.^{49–57} Ethically, the chief challenges associated with privacy and autonomy are when the ethical mandate to maintain privacy conflicts with others.

Regardless of the ethical paradigm used, maintaining patient privacy is an absolute ethical requirement for dermatologists. Pragmatically, if patients cannot rely on the privacy of their consultations, the fundamental physician–patient relationship may be undermined.^{58–61}

Duty and honesty

The issue of *duty* is important when considering ethical situations;^{18,36,62,63} most clinicians see themselves as obligated exclusively to the patient, and perceive that they have a fiduciary duty to their patient alone. In this context, an ethical choice may be interpreted as acceding to the patient's request.

A physician's duty, however, is not only to the patient; it is also to the profession, the healthcare system at large, and to the insurer with whom the clinician has a contractual relationship. From a principlist approach, this also touches on the principle of justice. Others have suggested that truth-telling itself is a principle, rather than a virtue.⁶⁴ Dermatologic surgeons should never take any steps that could erode patients' trust in physicians overall, as our standing—and thus our ability to have patients share openly and honestly—is based on perceived honesty and integrity.^{65–71}

Rationing

Appropriate use criteria (AUC) were developed jointly by the AAD, American Society for Dermatologic Surgery, American College of Mohs Surgery, and the American Society for Mohs Surgery, and have been widely popularized and adopted.^{72,73}

The ethics of this rationing behavior have not been exhaustively explored.^{74,75} Though it is tempting to accept AUC as de facto *ethical* guidelines, these criteria were developed with an eye to mitigating the risk of reimbursement restrictions through self-regulation. As one of the most costly treatments in dermatology, Mohs surgery has undergone significant scrutiny, and its cost effectiveness has been the subject of debate.^{76–80}

This touches on the issue of conflict of interest; it could also be argued, however, that there is no true *conflict* here at all. For the patient, Mohs surgery provides the greatest chance of tumor removal coupled with the smallest scar; for the physician, it provides the greatest reimbursement and the satisfaction of knowing that the patient's best interests were served. What duty does the physician have to the insurer beyond a contractual relationship? While this could be framed as a justice issue, would its outcome be different if the patient were insured through a state-funded plan or an expensive private insurer? On a pragmatic level, the patient's insurer may have a policy in place regarding reimbursement for Mohs in low-risk locations, though

patient preferences remain an important consideration when determining treatment options.

Cosmetic dermatologic surgery

Dermatologic surgeons perform a significant proportion of all cosmetic procedures worldwide.⁸¹ Patients may present for cosmetic intervention with a variety of concerns, and a reluctance to rely on paternalism, coupled with the economic realities of an out-of-pocket reimbursement schedule, has led to the embrace of a patient-as-client phenomenon. Yet the ethical obligations of the physician remain unchanged, regardless of whether the patient is presenting for cosmetic or medical treatment.

Body dysmorphic disorder is a common condition, and identifying such patients is an important challenge for the cosmetic dermatologist, not least because the patient is likely to be dissatisfied after *any* intervention.^{82–98} Ethically, performing a procedure on a patient with body dysmorphic disorder, or even a patient with clearly unrealistic expectations, is problematic. From a principlist standpoint, this would violate the principle of nonmaleficence and from a Kantian perspective, the physician's motivation is likely not the patient's best interests.

Clinical research

As with other situations resulting from solicitations, it is important to consider the *motivations* for performing clinical research. This Kantian approach is helpful in evaluating the ethical merits of performing this type of work, and the appropriate interactions that should take place both with the research sponsor and the clinical trial participants.

Clinical research is a burgeoning area in medicine overall, and indeed a necessary component in the development of both novel and generic medications.^{99–102} While it should not be pursued solely as a potential profit center, fair reimbursement for clinical research work is reasonable and indeed necessary.

Industry funding

Despite significant efforts to protect medical education from the impact of industry funding and potential bias, a significant proportion of continuing

medical education (CME) material is industry sponsored, either directly or indirectly.^{103–108}

Industry funding in dermatology is pervasive, as demonstrated by a recent manuscript highlighting the range of payments from pharmaceutical companies to dermatologists.¹⁰⁹ Accepting payments from industry is not ethically fraught per se, though significant evidence has demonstrated that even accepting drug samples has an impact on prescribing patterns.^{110,111}

CONCLUSIONS

Dermatologic surgeons face ethical challenges on a daily basis. A basic appreciation of the various approaches to ethical decision making is helpful for the practicing clinician as well as the academic dermatologic surgeon. Ultimately, most ethical guidelines set only a floor for ethical action, limiting frankly unethical actions. Aspiring to a higher level of patient-centered surgical care aids dermatologic surgeon and patient alike.

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CHAPTER 10 Billing and Financial Considerations in Dermatologic Surgery

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SUMMARY

- The goal of complete and accurate coding is to clearly define to a payer what was performed during a given patient care interaction.

- Each procedural charge submitted to a payer must be correlated with a valid diagnostic code.

Beginner Pearls



- Determine the excision code size by adding the maximum lesion diameter to that of the summed narrowest bilateral excision margins.
- If a patient evaluation leads to a 90-day global procedure done on the same day, then the evaluation and management service is separately billable with modifier .57 appended.

Expert Pearls



- Immunohistochemical stain coding is defined as per specimen, and not per block of tissue.
- Redundant tissue removal (standing cones or dog ears) does not elevate an otherwise linear closure procedure to the level of a flap, though it may turn an otherwise intermediate into a complex linear repair.

- When a defect or a portion of a defect is repaired with a Burow's graft generated from a linear excision and closure adjoining the defect, only the skin graft procedure is billable, as the graft code includes the excision and direct closure of the donor defect. Mohs surgery is still billable separately, though it may be subject to the multiple procedure reduction rule.

Don't Forget!



- When more than one repair of the same type (simple, intermediate, or complex) is done within one anatomical area, sum the lengths of the repairs and bill for one closure, as directed by the site and sum of the of the repair lengths. If repairs of the same type are done in different anatomical code group areas, then bill each one individually.
- A Z-plasty generated from the edge of a flap to promote the flap's mobility does not constitute an additional separate flap.

Pitfalls and Cautions



- Avoid using “unspecified” (NOS—Not Otherwise Specified) diagnostic codes, highlighted in yellow in the ICD-10 manual, as this indicates that the medical record lacked sufficient information for a more precise code selection. Some insurers may deny claims with “unspecified” codes.

- Excisions of epidermal inclusion and pilar cysts that extend into the subcutaneous space should be coded with the integumentary excision codes, as these entities are of skin, and not subcutaneous, origin.

Patient Education Points



- It is worth explaining to patients that physicians will bill insurance companies as a *courtesy* to them, but that ultimately it is the patient's responsibility to cover the cost of any procedures performed.
- Explaining that the surgeon is bound by the terms of a contract with the insurer helps the patient understand that the surgeon is indeed their ally.

CHAPTER 10 Billing and Financial Considerations in Dermatologic Surgery

INTRODUCTION

Surgical dermatology encompasses a variety of both therapeutic and cosmetic procedures. An appreciation of the techniques needed to optimally document the patient record and convey what was done into the billing system and, ultimately, to the payer, is of vital importance. Crucial to success in this arena is an understanding of both diagnostic and procedural billing definitions and parameters.

Although electronic health records and practice management programs may prompt diagnostic and procedure code selections, it is essential to be familiar with optimal diagnostic and procedural code definitions and correlations, as ultimately correct coding is the physician's responsibility. To that end, minimal essential coding sources are the latest ICD-10-CM diagnostic coding manual and the Current Procedural Terminology (CPT®) manual, both of which are available from the American Medical Association (AMA) and from other sources.

The billing process should consider whether a given entity and its treatment are considered medically necessary/covered services or not

medically necessary/not covered. Medicare, for example, excludes coverage for procedures not aimed at improving a patient’s health or function.

The goal of complete and accurate coding is to clearly define to a payer what was performed during a given patient care interaction. As this information is typically transmitted electronically via diagnostic, procedural, and modifier codes, it is essential to proper claim adjudication that the codes precisely define what was done, and that the patient record supports the transmitted billing data.

ESSENTIALS OF CODING

ICD-10-CM: diagnostic coding

Each procedural charge submitted to a payer must be correlated with a valid diagnostic code. The chart record must specify data facilitating precise code selection. This includes a specific diagnosis or tumor type, including anatomic location and laterality. The billing system and/or biller should be able to successfully select an appropriate diagnostic code based upon the submitted information. Similarly, insurers, upon chart audit, should be able to readily extract the same information from the patient record.

ICD-10 code selection should be performed to the highest level of specificity available within each code set. If a code listed in the ICD-10 manual is accompanied by an adjacent red box, then the more detailed codes below this listing should be selected, as insurers are unlikely to pay for an inadequately specific diagnosis code. Essential documentation and code selection steps for ICD-10 coding are summarized in [Table 10-1](#). It is important to note that common (e.g., basal cell carcinoma, squamous cell carcinoma, benign nevi) and some rare tumors (e.g., Merkel cell carcinoma) have dedicated diagnostic codes, while many others do not. If the tumor diagnosis is known, then select a tumor-specific code. If a specific code is not available, then select an “other specified malignant neoplasm” site-specific code. [Table 10-2](#) provides a listing of common skin neoplasms and their ICD-10 code series.

Table 10-1. Essential ICD-10 Coding Parameters

- Tumor type
 - Specific diagnosis known
 - Use tumor-specific code if available
 - Specific code not available: use “other specified malignant neoplasm” code
 - Uncertain diagnosis: neoplasm of uncertain behavior: D48.5 (skin); D37.01 (lip mucosa)
 - Tumor location—always specify
 - Laterality—left or right
-

Table 10-2. ICD-10-CM Codes for Common Cutaneous Neoplasms

Tumor	ICD-10 Code Series
Actinic keratosis	L57.0
Basal cell carcinoma	C44 series
Benign neoplasm, lip mucosa	D10.0
Benign neoplasm, penis	D29.0
Benign neoplasm, scrotum	D29.4
Benign neoplasm, skin	D23 series
Benign neoplasm, vulva	D28.0
Cherry angioma	I78.8
Cyst, eyelid	H02.82 series
Cysts, other, follicular, of skin	L72.8
Epidermal inclusion cyst	L72.0
Hemangioma	D18.01
Hypertrophic scar	L91.0
Lipoma	D17 series
Malignant melanoma	C43 series
Malignant neoplasm, lip vermilion	C00. series
Malignant neoplasm, type known	C44 series
Mass/swelling	R22 series
Melanoma in situ	D03 series
Merkel cell carcinoma	C4A series
Neoplasm, uncertain behavior	D48.5
Nevus, melanocytic	D22 series
Pilar cyst	L72.11
Port wine stain	Q82.5
Pyogenic granuloma	L98.0
Sebaceous cyst (steatocystoma)	L72.3
Seborrheic keratosis	L82.1
Seborrheic keratosis, inflamed	L82.0
Spider angioma	I78.1
Squamous cell carcinoma	C44 series

Squamous cell carcinoma in situ, penis	D07.4
Squamous cell carcinoma in situ	D04 series
Strawberry angioma	Q82.5
Trichodermal (proliferating pilar) cyst	L72.12
Venous lake	I78.8

When a patient evaluation consists substantially of monitoring for new or recurrent tumor appearance, one may justify the visit with an ICD-10 diagnosis of personal or family skin cancer history, listed in [Table 10-3](#).

Table 10-3. Personal or Family History of Malignant Neoplasm ICD-10 Codes

Z85.42	Personal history of malignant neoplasm of other female genital organs
Z85.49	Personal history of malignant neoplasm of other male genital organs
Z85.818	Personal history of malignant neoplasm of other sites of lip, oral cavity
Z85.820	Personal history of malignant melanoma of skin
Z85.821	Personal history of Merkel cell carcinoma
Z85.828	Personal history of other malignant neoplasm of skin (BCC, SCC, others)
Z85.831	Personal history of malignant neoplasm of soft tissue
Z80.8	Family history of malignant neoplasm of other organs or systems (may be used for specifying family history of melanoma)

Coding Hint: Avoid using “unspecified” (NOS—Not Otherwise Specified) diagnostic codes, highlighted in yellow in the ICD-10 manual, as this indicates that the medical record lacked sufficient information for a more

precise code selection. Some insurers may deny claims with “unspecified” codes.

Current Procedural Terminology: procedural coding

The CPT® manual specifies numerical or alphanumeric codes for medical services. These codes are linked to appropriate ICD-10-CM diagnostic codes for the purposes of transactional record-keeping and billing.

Essential to the process is an understanding of the CPT® manual, which contains several sets of codes. Category I numerical codes represent the bulk of the manual, and are used for specifying most physician services. Category II codes, consisting of four numbers followed by the letter F, are tracking/performance measurement codes, and may be used for data collection. They are typically not necessary for billing. These codes are distinct from the “quality” reporting measures that may be reported for the purpose of avoiding Medicare payment reductions. Category III codes are temporary codes defining emerging technology, services, or procedures. They are sometimes reimbursable, are also used for tracking utilization of the item that they specify, and should be used whenever a service specified by those codes is provided. They are identified by four numbers followed by the letter T. Dermatology is served by several Category III codes ([Table 10-4](#)). These codes may eventually be changed to Category I codes if their utilization/reporting were to support such a need. Appendix A of the CPT® also lists modifier codes, which will be addressed further in this chapter.

Table 10-4. Dermatology-Related Category III CPT Codes

0394T	High-dose-rate electronic brachytherapy, skin surface application, per fraction, includes basic dosimetry, when performed
0400T	Multispectral digital skin lesion analysis of clinically atypical cutaneous pigmented lesions for detection of melanomas and high-risk melanocytic atypia; one to five lesions
0401T	Multispectral digital skin lesion analysis, six or more lesions

COMMON DERMATOLOGIC SURGERY CODES

Most dermatology-related CPT codes appear in the Integumentary System section of the codebook (codes 10030–19499). All of these procedure codes include local anesthesia in their definitions.

Biopsy: 11100 and 11101

Definition: Removal or sampling skin tissue or mucous membrane for histopathologic examination. The depth of the biopsy may extend partially into the skin or through the skin, encompassing underlying subcutaneous or muscle tissue. Suturing may or may not be necessary. While the code definition specifies skin or mucous membrane biopsy, there are several other, site-specific biopsy codes that may be utilized. Since coding should be performed to the most exacting specificity, the site-specific codes ([Table 10-5](#)) should be utilized when appropriate. For skin biopsies, the same code is applied, regardless of the depth and the width of the biopsy.

Table 10-5. Site-Specific Biopsy Codes

CPT Code	Definition
11100	Biopsy of skin, subcutaneous tissue, and/or mucous membrane (including simple closure)
11101	Each separate/additional lesion
11755	Biopsy of nail unit (plate, bed, matrix, hyponychium, proximal, and lateral nail folds)
30100	Biopsy, intranasal
40490	Biopsy of lip mucosa
40808	Biopsy, vestibule of mouth
41100	Biopsy of tongue; anterior two-thirds
41105	Biopsy of tongue; posterior one-third
41108	Biopsy of floor of mouth
54100	Biopsy of penis
56605	Biopsy of vulva or perineum; 1 lesion
56606	Biopsy of vulva or perineum, each separate additional lesion
67810	Incisional biopsy of eyelid skin including lid margin
69100	Biopsy external ear

Coding Hint: CPT® code 67810 is to be used only when lid margin, extending across the lash line to the conjunctival mucosa, is biopsied. Biopsy of the skin of the eyelid is to be coded with 11100 or 11101.

Shaving of epidermal or dermal lesions: 11300–11313.

Definition: Removal of epidermal or dermal lesions via a transverse, horizontal incision. Proper codes are determined by the maximum *diameter* of the removed lesion. Depth of lesion removal does not penetrate into the subcutaneous fat. No suturing is required for this coding level. Code selection requires specifying the location and diameter of the lesion. Typical

use of a shave code would be to specify tangential removal of a benign nevus, a fibrous papule, a cherry angioma, or a seborrheic keratosis.

Coding Hint: If the depth of lesion removal extends beyond the dermis, into the subcutaneous space, then a shave removal code is not appropriate. Select a biopsy or excision code.

Excisions, benign and malignant: 11400–11646

Definition: Full-thickness (through the dermis) lesion removal, including margins, and simple closure. The CPT does not require that the closure of a defect be performed in order to qualify for an excision code. The appropriate code is determined by the lesion location and the maximum diameter of the lesion including the narrowest margin required bilaterally. The lesion and margin measurements must be performed prior to the actual excision, as following an excision the tissue tends to rebound away from the excision center, thereby enlarging any diameter measurement (Fig. 10-1). The integumentary excision codes include local anesthesia and a simple (nonlayered) repair in their definition and valuation. Whenever an intermediate or complex repair is necessary, it is coded in addition to the appropriate excision code.

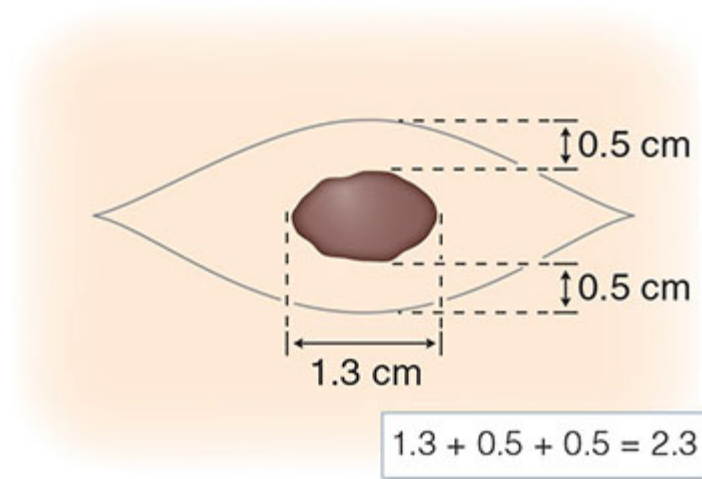


Figure 10-1. When billing for an excision, add the largest diameter of the defect as well as any necessary margins.

Coding Hint: Determine the proper code by adding the maximum lesion diameter to that of the summed narrowest bilateral excision margins prior to excision.

Several localized special excisional procedures are characterized by their own descriptive excision codes, listed in [Table 10-6](#). Note that the excisions in [Table 10-6](#) include closure, even when not specified, so that separate intermediate or complex repair should not be coded in addition to the excision code.

Table 10-6. Special Excision Procedure Codes

Nail Unit	
11750	Excision of nail and nail matrix, partial or complete, for permanent removal
Nose	
30120	Excision or surgical planning of skin of nose for rhinophyma
Lips	
40500	Vermilionectomy (lip shave), with mucosal advancement
40510	Excision, transverse wedge excision with primary closure
40520	V-excision with primary direct linear closure
40530	Resection of lip, more than one-fourth, without reconstruction
Mouth Vestibule	
40810	Excision of lesions of mucosa and submucosa; without repair
40812	With simple repair
40814	With complex repair
40816	Complex, with excision of underlying muscle
Tongue	
41110	Excision of lesion of tongue without closure
41112	Excision of lesion of tongue with closure; anterior two-thirds
Ear	
69110	Excision external ear; partial, simple repair

There are some similarities and some clear distinctions between the biopsy, shave, and excision code definitions. [Table 10-7](#) characterizes the commonalities as well as the distinctions between these three code families.

Table 10-7. Biopsy versus Shave versus Excision

Procedure	CPT® Code	Select Code by Location?	Select Code by Diameter?	Depth	Code Includes	Code Distinguishing Features	Submitted for Pathology?
Biopsy	11100, 11101	No	No	Any: not specified	Simple closure	Biopsy of skin, mucous membrane or subcutaneous tissue	Yes
Shave	11300–11313	Yes	Yes: lesion diameter	Epidermis or dermis only	Chemical or electric cauterization	No suture closure	Usually
Excision	11400–11646	Yes	Yes: greatest lesion diameter + margin	Full thickness, through dermis	Excision with margins; simple closure	Report intermediate or complex repair separately; closure not required for use of code	Yes

Soft tissue excision (musculoskeletal section of CPT®)

Codes specifically dedicated to the excision of subcutaneous and subfascial tumors are grouped in multiple locations within the musculoskeletal section of the CPT®, starting with code 21011 for an excision of a subcutaneous tumor less than 2 cm in diameter on the face or scalp, and ending with 28041 and 28045 for subfascial tumor excisions on the foot or toe.

These specialized codes are appropriate for the resection of typically benign tumors of subcutaneous or subfascial origin, such as lipomas. Code selection is based upon tumor location on the body, whether it is subcutaneous or subfascial in origin, and upon its maximum diameter being either above or below a limit specified by an individual code. The medical record should substantiate the depth of excision and the type of tumor excised. Radical resection codes, such as 21015 for face or scalp, are major procedures reserved for aggressive tumor resections, such as deep tissue sarcomas.

Coding Hint: Excisions of epidermal inclusion and pilar cysts that extend into the subcutaneous space should be coded with the integumentary excision codes, as these entities are of skin, and not subcutaneous, origin.

Repairs

All repair codes include local anesthesia and wound closure with sutures, staples, or tissue adhesives. Closure with adhesive strips only does not merit

a repair code, and is included in an evaluation and management code. Code selection is based upon location and measured length of the repair.

Coding Hint: When more than one repair of the same type (simple, intermediate, or complex) is done within one anatomical area, sum the lengths of the repairs and bill for one closure, as directed by the site and sum of the repair lengths. If the repairs of the same type are done in different anatomical code group areas, then bill each one individually.

Simple repair: 12001–12021

Definition: Single-layer closure for a usually superficial wound. Biopsy and excision codes include a simple repair. However, Mohs surgical excisions do not. Consequently, other than for the repair of traumatic skin injuries, one is most likely to use a simple repair code in conjunction with a Mohs surgical defect repair.

Intermediate repair: 12031–12057

Definition: Specifies “wounds that, in addition to simple repair, require layered closure of one or more deeper layers of subcutaneous tissue and (nonmuscle) fascia, in addition to the skin (epidermal and dermal) closure.” Typically, the medical record would include a justification for an intermediate repair, such as reducing closure line tension, obliterating dead space, or providing stability to the wound. Rarely, an intermediate repair may be justified when extensive removal of particulate matter is done prior to a single-layer closure.

Complex repair: 13100–13153

Definition: These repairs are more involved than a layered closure, and include any of the following: scar revision, debridement, extensive undermining, dog-ear correction, stents, or retention suture placement. The most common dermatologic surgical justification for complex repair coding is extensive (broad) undermining, though this definition is not specifically addressed in the CPT® or other official publications. The breadth of

undermining required to qualify as “extensive” will vary by anatomical site as, for example, what one may consider to be broad undermining on the nose tip would not necessarily be the same as that on a cheek. It is clear, however, that undermining done minimally beyond the wound edges in order to optimize apposition is not extensive undermining. Consequently, undermining alone does not justify a complex repair code. It has to be extensive (broad), and documented as such. Also, document why extensive undermining was performed, such as due to tension across the wound or to reduce distortion. The repair of Burow’s triangles (standing cones or dog-ears) is included in this code.

Coding Hint: The length of a repair of standing cones (Burows triangles, “dog ears”) is contiguous with the principal repair itself, and should be included in the final repair length measurement.

Clinical Scenario: Your patient returns with a wound dehiscence, which you clean and repair. How do you code for the procedure? If the procedure is, in your judgment (and documented), extensive or complicated, use CPT® 13160, Secondary closure of surgical wound or dehiscence, extensive or complicated. If it requires a simple closure, use CPT® 12020, and if packing was included, then use 12021.

Destruction: 17000–17004, 17100–17111, 17260–17286

The destruction code set is principally stratified into two major sections, one dedicated to the destruction of malignant lesions, and the other for benign or premalignant entities. Both categories include destructions by “any method,” examples being laser surgery, electrosurgery, cryosurgery, chemosurgery, and surgical curettage. Specialized destruction categories are dedicated to vascular proliferative lesions (17106–17108) and to the chemical cauterization of granulation tissue (17250). Typically, no tissue is submitted for histopathology prior to the destruction of a benign or premalignant lesion, but there is nothing in the codes prohibiting histopathologic examination, if that were medically necessary. The CPT also offers some special, site-specific destruction codes ([Table 10-8](#)).

Table 10-8. Site-Specific CPT® Destruction Codes

■ 40820	Vestibule of mouth, by physical methods
■ 46900	Anus, simple; chemical
■ 46910	Simple, electrodesiccation
■ 46916	Simple, cryosurgery
■ 46917	Simple, laser surgery
■ 46922	Surgical excision
■ 46924	Anus, extensive ^a (laser, electrosurgery, cryosurgery, chemosurgery)
■ 54050	Penis, simple; chemical
■ 54055	Simple, electrodesiccation
■ 54056	Simple, cryosurgery
■ 54057	Simple, laser surgery
■ 54060	Surgical excision
■ 54065	Penis, extensive ^a (laser, electrosurgery, cryosurgery, chemosurgery)
■ 56501	Vulva, simple (laser, electrosurgery, cryosurgery, chemosurgery)
■ 56515	Vulva, extensive ^a (laser, electrosurgery, cryosurgery, chemosurgery)

^a“Extensive” is not specifically defined in the CPT.

Malignant destruction: 17260–17286

Coding is specified by lesion location and diameter, performed either prior to the destruction, after curettage, or after electrodesiccation or chemical hemostasis. As curettage may reveal substantial subclinical extension of a tumor, it is best to measure after curettage, as that will yield the most accurate indication of a lesion’s diameter. Electrodesiccation can shrink the apparent diameter, so it is prudent to avoid measurements following electrodesiccation, if curettage is first done. It is helpful to identify in the medical record both the lesion diameter and at which point it was measured (i.e., following curettage). The depth of curettage is not required to be recorded, but can be useful for evaluating the risk of tumor recurrence.

Coding Hint: If one of the first samples is presumed malignant tissue for histopathologic evaluation immediately prior to its destruction, then no separate biopsy or shave removal charge is allowed. The removal of the lesion in the setting of its destruction is included in the destruction code set.

Mohs micrographic surgery: 17311–17315

Definition: Removal of skin cancer with histologic examination of 100% of surgical margins. A qualifying requirement is that the physician functions as both a surgeon (excises the cancer) and pathologist (interprets the Mohs histology slides). Mohs surgical codes are stratified by a primary (17311, 17313) location-based code for the first stage of excision and a corresponding add-on code (17312, 17314, respectively) for each additional stage. Each of the stages includes processing tissue into up to five blocks. If more than five blocks are required for a stage, then 17315 is coded for each additional block per stage beyond five ([Table 10-9](#)). A block is defined as an individual tissue piece or pieces embedded in a mounting medium on a tissue plate. It is the number of separate tissue plates needed to process a tissue specimen in a given stage that determines the number of blocks, and not the number of pieces of tissue on a plate. Staining with hematoxylin and eosin or toluidine blue, or both, is included in the Mohs definition. Other, special histochemical stains may be coded with 88314.59, reported once per block. Immunohistochemical stains, such as melan-A, are specified with 88342.59 for a single antibody stain per specimen, and 88341.59 for each additional, distinct antibody stain, per specimen (not per block).

Table 10-9. Mohs Surgery Codes

Each Mohs stage includes:

- Staining with a “routine” stain: hematoxylin and eosin, and/or toluidine blue
- Processing of tissue into up to five tissue blocks

17311	First stage: head, neck, hands, feet, genitalia; any location involving muscle, cartilage, bone, tendon, major nerves, or vessels
17312	Each additional stage after the first stage
17313	First stage: trunk, arms, legs
17314	Each additional stage after the first stage
17315	Each additional tissue block over five blocks per stage

Coding Hint: Immunohistochemical stain coding is defined as per specimen, and not per block of tissue. A specimen is a distinct piece of tissue excised in a Mohs stage. If one specimen is sectioned into multiple pieces, each processed on a separate block, one would charge for one unit of 88342 histochemical staining. However, if a Mohs stage required an excision of two separate, noncontiguous tissue specimens from two separate portions of the defect margin, and each of these was stained immunohistochemically, then two units of 88342 would be billed.

In 2013, Medicare issued a Medicare Learning Network (MLN) Matters article (<https://www.cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNMattersArticles/Downloads/SE1318.pdf>) defining qualification and documentation criteria for Mohs surgery. These criteria have been widely adopted by individual Medicare Administrative Contractors, the entities charged with adjudicating claims. As the Medicare patient population continues to expand, it is wise to incorporate the MLN Mohs article’s requirements into charting. The salient features are summarized in [Table 10-10](#).

Table 10-10. Mohs Surgical Documentation, Based upon MLN 2013 “Guidance to Reduce Mohs Surgery Reimbursement Issues”

Documentation Supporting the Choice of Mohs Surgery

- "Complexity" of a lesion: poorly defined borders (indistinct clinical margins), deep invasion, recurrence, prior irradiation
- Lesion size or location (on anatomically or functionally critical site)
- Maximum conservation of healthy tissue

Qualifications and Limitations of Coverage

- Mohs surgeon must be a physician: MD or DO
- Physician must be skilled and trained in Mohs surgery and pathology interpretation
- Physician performs both the surgery and the specimen interpretation (this must be documented in the operative report)

Operative Documentation

- Location, number and size of the Mohs treated lesion(s)
- Number of stages performed
- Number of specimens per stage

Histology Documentation

- First stage:
 - Depth of invasion
 - Pathological pattern of the tumor
 - Cell morphology
 - Perineural invasion or scar tissue, if present
- Subsequent stages:
 - If tumor characteristics are unchanged, note this only
 - If tumor characteristics are different, describe the differences

Mohs surgery special circumstances

Mohs surgery continued on a subsequent day.

The MLN article directs one to start with a first stage code when a Mohs surgery is continued on a subsequent day. Example: Four stages, nose, on day one: 17311, 17312 × 3; two stages on day two: 17311, 17312.

Biopsy done to confirm the presence and type of tumor on the day of Mohs surgery, when no biopsy was previously performed.

One would do a diagnostic biopsy and a diagnostic frozen section tissue processing and reading. The proper billing would be: 11100.59 for the biopsy and 88331.59 for the frozen section pathology. The .59 modifier indicates that both the biopsy and the frozen section are separate, distinct services that should not be bundled with the Mohs surgery adjudication. The Mohs surgery would be billed without a modifier.

Two separate Mohs sites/surgeries on one patient, one day.

First site: code routinely for Mohs.

Second site: append .59 modifier to all codes. (Medicare contractors may require appending .76 modifier (“Repeat procedure or service by the same physician or other qualified health care professional”), instead.

Biopsy of a totally distinct lesion done on the same day as Mohs surgery.

Bill Mohs surgery routinely.

Bill biopsy as 11100.59 or 11100.76 (if Medicare patient).

Decision to do Mohs surgery is made on the same day as the Mohs surgery.

If a patient evaluation led to a Mohs surgery recommendation, and the surgery was done on the same day, one may bill for an appropriate level of evaluation and management (E/M) service in addition to the Mohs surgery. The E/M would be billed with an appended .57 modifier, indicating that that an E/M evaluation that led to a decision to perform Mohs surgery was done on the same day as a major surgical procedure.

Adjacent tissue transfer or rearrangement (flaps): 14000–14302

Definition: Includes excision of a lesion as well as a repair of the defect by adjacent tissue transfer or rearrangement, with one exception: Mohs surgery-generated excisions are separately billable from any repair code, including flap repairs. The CPT® specifies that the extent of undermining to generate tissue motion does not make the procedure a flap. For example, broad undermining of a cheek to facilitate “advancing” it to close a nasofacial sulcus or preauricular defect linearly does not constitute a flap procedure. Proper flap codes are determined by the location of the defect and by the measured square centimeters of the primary defect plus that of the secondary

defect created by the raised (detached) portion of the flap. This sum constitutes the “defect” size. The CPT® provides code selection based upon lesion location and defect surface areas of 10 cm² or less, 10.1 to 30.0 cm², 30.1 to 60.0 cm², any area (14301), and each additional 30.0 cm² beyond 60.0, any area (14302).

Coding Hint: Redundant tissue removal (standing cones, Burows triangles, “dog ears”) does not elevate an otherwise linear closure procedure to the level of a flap. (CPT Assistant, April 2014, page 10).

There are flaps (CPT® 15570–15738) outside of the adjacent tissue rearrangement section that are used in dermatologic surgery (Table 10-11). One should avoid using code 15740: *Flap; island pedicle requiring identification and dissection of an anatomically named axial vessel* unless the strict criterion for its use (identifying and dissecting out a named vessel) is met. Just because a named vessel may be identified and contained in the body of a V-Y flap (but not dissected out) does not qualify a repair as an island pedicle flap.

Table 10-11. Special Flap Codes

15570	Formation of direct or tubed pedicle, with or without transfer; trunk ^a
15572	Scalp, arms, or legs
15574	Forehead, cheeks, chin, mouth, neck axillae, genitalia, hands, or feet
15576	Eyelids, nose, ears, lips, or intraoral
15600	Delay of flap or sectioning of flap (division and inset); at trunk
15610	At scalp, arms, or legs
15620	At forehead, cheeks, chin, neck, axillae, genitalia, hands, or feet
15630	At eyelids, nose, ears, lips
15650	Transfer, intermediate, of any pedicle flap, any location ("walking tube")
15731	Forehead flap with preservation of vascular pedicle (paramedian forehead flap)
40525	Full thickness lip reconstruction with local flap (Estlander or fan)
40527	Full thickness lip reconstruction with cross lip flap (Abbe–Estlander)

^aThe specified location is that of the recipient defect site (not the donor area).

Coding Hint: A bilateral advancement flap constitutes one flap with two sections, just as a bilobed transposition flap is one flap with two lobe components. A Z-plasty generated from the edge of a flap to promote the flap's mobility does not constitute an additional separate flap. In the above cases, one would bill based upon the sum of the measured surface areas of the excision defect plus that of all of the raised flap components, including any Z-plasty.

Skin Replacement Surgery (Grafts): 15002–15278

This section has steadily expanded as technology has facilitated the development of skin substitutes. Coding is determined by the type of graft utilized, the location onto which it is placed, and the square centimeter surface area of the defect covered by the graft. Full-thickness skin graft codes (15200–15261) include excision of the donor skin and direct closure of the donor site. A complicated repair of a surgical defect may require a combination of a flap repair as well as a skin graft. In such cases, both the flap and the graft are separately billable.

Coding Hint: When a defect or a portion of a defect is repaired with a “kite graft” or a Burows graft generated from a linear excision and closure adjoining the defect, only the skin graft procedure is billable, as the graft code includes the excision and direct closure of the donor defect.

GENERAL CONSIDERATIONS

Global surgical periods

Each surgical CPT code is presently assigned a global surgical period, which indicates a time of 0, 10, or 90 days postprocedure during which routine office visits related to the procedure are not billable, as payment for such is included in the surgery valuation. Routine visits include wound checks, patient counseling, bandage changes, and suture removal (Table 10-12). Any necessary services provided following a 0-day global procedure are billable. Ten-day global periods include the day of the procedure plus 10 days starting on the day after the procedure. Ninety-day global periods include the day before, the day of, and 90 days starting the day after a surgery. Common dermatologic surgical codes and their global periods are listed in Table 10-13.

Table 10-12. Services Included in a Global Period

-
- Preoperative visits: day of surgery for 10-day global (minor) procedures and day before surgery for 90-day global (major) procedures

- Postoperative complications not requiring a return to the operating room (e.g., hemorrhage, infection)
- Postoperative follow-up visits
- Dressing changes, surgical site care, removal of sutures or staples
- Decision to perform a minor (10-day global) procedure made on the day of the procedure

Table 10-13. Common Dermatology-Related Global Periods and CPT Codes

0 Days	10 Days	90 Days
Biopsy (11100, 11101)	Destruction (17000–17286)	Flaps (14000–14301; 15570–15760)
Shave removal (11300–11313)	Excisions (11400–11646)	Grafts (15050–15260; 15760)
Debridement (11000–11043)	Repairs (12001–13153)	Tissue expanders
Mohs surgery (17311–17315)		Destruction of vascular Proliferative lesion (17106–17108) Dermabrasion, chemical peel.

Coding Hint: If a patient evaluation leads to a 90-day global procedure done on the same day, then the evaluation and management service is separately billable, with modifier .57 appended (see Modifiers, below).

Modifiers

Appendix A of the CPT® lists numerical modifiers that are to be appended to CPT codes to distinguish certain services or situations. Whenever an E/M encounter or a billable procedure is performed during the global period, one must append an appropriate modifier to the primary billing code to specify that the service provided is unrelated to the global period service (Table 10-14).

Table 10-14. Modifiers Commonly Used in Dermatologic Surgery

- 24: Unrelated E/M service by the same physician or other qualified health care professional during a postoperative period

- 25: Significant, separately identifiable E/M service by the same physician or other qualified health care professional on the same day of the procedure or other service
 - 57: Decision for surgery (refers to E/M service resulting in a decision to perform a 90-day global surgery the day of or day after the evaluation)
 - 58: Staged or related procedure or service by the same physician or other qualified health care professional during the postoperative period
 - 59: Distinct procedural service (append to distinguish additional procedures performed on one day)
 - 76: Repeat procedure or service by same physician or other qualified health care professional
 - 79: Unrelated procedure or service by the same physician or other qualified health care professional during the postoperative period
-

Therefore, this entails tracking of preceding services and their global periods. Modifier .24 is appended to E/M codes during the Global Period, and .79 is added to surgical/procedural codes billed during the Global Period. When a distinct, separately identifiable E/M service is provided on the day of a procedure, one appends modifier .25 to the E/M service code. The patient record should support such a claim. Routine billing of an E/M code along with every procedure will cast one as an outlier biller, and is likely to eventually result in insurance company action, such as in the form of a focused chart audit.

Occasionally, one will perform a second procedure, related to the first, during the global period. Typical scenarios include a wide excision of a melanoma within 10 days following an initial, diagnostic excision, or a division and inset of an interpolation flap during its 90-day global. Such services require appending a .58 modifier, indicating that the second procedure is a consequence of the first.

Finally, dermatologic surgeons commonly perform more than one procedure, such as multiple malignant neoplasm destructions, or actinic keratoses destructions along with unrelated lesion biopsies or destructions, during one patient encounter. Insurers must distinguish that the procedures done were separately identifiable and individually payable. Modifier .59 specifies distinct procedural services, and should be appended to secondary procedures done on one day. Medicare, however, may require a .76 modifier

when two or more procedures are done for an identical diagnosis, or when the two procedures have the same CPT® procedure code. Thus, if a Medicare claim that seems properly coded with a .59 modifier is rejected, one should consider appending a .76 modifier instead.

The choice of which code should have no modifier (primary code) and which should have a modifier is based on the National Correct Coding Initiative (NCCI), a project of the Centers for Medicare and Medicaid Services (CMS) dedicated to promoting correct coding and generating guidelines so as to avoid improper payments for Medicare outpatient services. The entity generates a Policy Manual for Medicare Services, and quarterly updated procedure-to-procedure (column 1/column 2) edits that specify whether a service paired with another is covered, and if so, which should be subject to the .59 modifier. Figure 10-2 illustrates the format of the NCCI edits and commonly used edits. The NCCI may be accessed at <http://www.cms.gov/Medicare/Coding/NationalCorrectCodInitEd/NCCI-Coding-Edits.html/>

Col 1	Col 2		19970101*		Modifier allowed? (1 = Yes)
17260	11100		19970101*		1


 Code in Col 2 gets the modifier


 Effective date of edit

Figure 10-2. NCCI edits demonstration. These tables dictate which procedure code receives a modifier for each distinct code pair.

General NCCI edits guideline:

- ✓ When a malignant destruction is done on the same encounter as a biopsy, append the .59 modifier to the biopsy code.
- ✓ When a premalignant destruction (17000) is done on the same encounter as a biopsy (11100), malignant destruction (17260–17286), benign or malignant excision (11400–11446; 11600–11646), append a .59 modifier to the biopsy, destruction, or excision codes
- ✓ Add-on codes (e.g., 11101 and 17003 do not merit a .59 modifier, as only the primary code receives the modifier)

Insurance coverage policies

Compulsively correct coding will yield no reimbursement if the procedures that are done are not considered medically necessary or are noncovered services. To that end, it is useful to know whether an insurer is likely to cover a given service. With Medicare, coverage decisions are typically reached in a transparent and reproducible fashion. CMS publishes National Coverage Determinations (NCD) that specify coverage for certain conditions. Specific to dermatology is the actinic keratosis NCD, which states that treatment of actinic keratoses is a covered service. Of greater use and impact are the Medicare Administrative Contractors' Local Coverage Determinations (LCDs), which are coverage documents issued for select conditions or procedures as a consequence of high utilization, suspected or proven fraud and abuse, due to a perception of overuse, and to standardize criteria for documentation and coverage. The LCDs specify coverage criteria, covered ICD-10 codes, pertinent CPT codes, and documentation requirements. If one fails to satisfy the LCD requirements, payment may not be forthcoming, or a refund may be requested upon audit. That should be a sufficient reason to be familiar with LCD content. The most common LCDs are for Mohs surgery and benign skin lesion treatments. The LCDs can be readily accessed from the relevant Medicare Administrative Contractor (MAC) websites.

Advanced Beneficiary Notice

The Advanced Beneficiary Notice (ABN, form CMS-R-131) is a written notice that the physician must provide to a Medicare fee-for-service patient before delivering services that are usually covered by Medicare but are not expected to be paid in a specific instance for a specific reason such as "lack of medical necessity." The ABN allows the Medicare beneficiary to be made aware that Medicare likely won't pay, and they can decide whether or not to have the procedure done. When an ABN is required, and the patient has been properly instructed and has signed the form, you can then receive payment from the patient. If Medicare feels that the ABN is invalid or if you failed to obtain one when indicated, you may be financially liable if Medicare does not pay. If payment was collected from the patient in this instance, the payment must be refunded in a timely manner. Items not covered under Medicare are listed on the CMS website at <https://www.cms.gov/Outreach-and-Education/Medicare-Learning-Network->

[MLN/MLNProducts/Downloads/Items-and-Services-Not-Covered-Under-Medicare-Booklet-ICN906765.pdf](#).

Billing Hint: If unsure as to whether a service will be covered by the patient's insurer, have the patient sign a fully filled-out ABN, available from the MAC or CMS website, prior to providing the service.

Cosmetic procedures

Report either ICD-10 code Z41.1 *Encounter for cosmetic surgery* for procedures that are strictly cosmetic in nature (such as nontherapeutic toxin injections or fillers) and then the 17999 CPT code with whatever price was quoted to the patient, or Z41.8 *Encounter for procedure for purposes other than remedying health state* when the procedure may not be considered cosmetic in all circumstances, but is in a particular case (nonirritated benign moles or skin tags), whichever is most appropriate, and then the CPT code for whatever procedure was done.

Insurer's perspectives

Health insurance will typically cover services that are both reasonable and necessary. It is incumbent upon the medical practitioner to record data supporting the decisions for care. If, upon chart audit such information is not discoverable, a claim may be denied. Each insurer may also have its own requirements for coverage or preferred claims adjudication criteria. Inappropriate denials of claims should be discoverable within one's practice. This requires a feedback and information sharing system between the billing/collections department and those actually doing the charting and generating billing: the medical care providers. This interactive interplay will facilitate discovering and correcting faulty billing patterns and/or record-keeping, and will stimulate appeals of improperly unpaid or underpaid claims.

Keep in mind that insurers utilize systems that analyze individual billing patterns, comparing them to a normal distribution curve of billings. If a practice's billing pattern rises to two standard deviations above the norm, then that practice is more likely to catch the insurer's attention, and be

audited. Examples of falling into such auditing criteria would be if all or nearly all of one's Mohs surgical cases required two or more stages for clearance, or if all linear repairs were complex repairs. If exposed to a focused audit, one would have to prove, case by case, why each patient required the complexity of care that they received.

Another subject for insurers' concern is overall cost of care. If a given practice is particularly costly to the system, then that system may want to investigate why, or may even want to drop the practice from its provider panel. It would then be up to the practice to prove why they have the expensive patient care mix, and how their practice is essential for the care of the insured patients. Insurers, and particularly Medicare Administrative Contractors, are concerned about "cloning" of chart material, whereby patient data is passed on virtually verbatim from one encounter to the next. Although cloning of individual surgical encounters is less likely, it is possible, particularly via electronic health records system facilitation, to have surgical procedure verbiage that is identical from one to another surgery, and from one patient to another. It is helpful to insert case-specific nuances into the surgical report, so that all reports do not seem identical. Finally, surgical reports should allow for extraction of pertinent care and billing data.

CONCLUSIONS

Accurate and precise coding and billing require the dermatologic surgeon to work in a logical and precise fashion. Documenting the medical necessity for every procedure is of paramount importance, and linking each procedure code to the appropriate ICD-10 diagnosis code, as well as to modifiers, if needed, will permit payers to rapidly and reliably decide on the merits of an individual surgeon's coding. Attention to detail ultimately results in fewer denials and rejections, a higher paid claims rate, a lower audit rate, and a smoother billing experience overall. Ultimately, it is the surgeon's responsibility to be familiar with the relevant coding, billing, and documentation requirements, and working as a team with the biller and collector will allow the surgeon to maintain their focus on the most important goal of all—outstanding patient care.

CHAPTER 11 Clinical Research in Dermatologic Surgery

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SUMMARY

- The central tenet of clinical research is answering a concrete, researchable question that addresses an uncertainty that the investigator wants to resolve.

- Clinical research is a broad, umbrella term that encompasses many types of scientific investigation including clinical trials as well as epidemiologic, behavioral, outcomes, or health services research.
- Many of the high-quality surgical techniques and improvements in clinical care enjoyed by dermatologic surgeons today result from clinical research physician–scientists.

Beginner Tips



- The foundation of any clinical research project is a clinically significant and impactful research question.
- A thorough review of the literature surrounding the clinical research hypothesis is necessary to establish the context of the work and to give it meaning.
- A systematic method for organizing and archiving the literature search is essential.

Expert Tips



- Understanding basic statistical concepts and tools can help reduce bias from potential confounding variables and improve the understanding of the application of clinical findings.
- Prior to initiating a study, a power analysis should be performed in order to determine the minimal number of data points required to reveal a significant result.
- Additional preparation for undertaking clinical research in dermatologic surgery includes refining skills in areas such as study design and biostatistics.
- The p -value is a measure of the likelihood that the result could be seen by chance. Overall, a p -value <0.05 , or less than 5%, is considered the threshold for being statistically significant; however, the lower the p -value, the more likely the result is to be true.

Don't Forget!



- Clinical trials that have one or more sites in the United States or that test a drug or device that is manufactured in the United States or its territories must be registered with ClinicalTrials.gov.
- In some cases, rigorous inclusion and exclusion criteria may select for ideal patients that fail to reflect a general population. Thus, the results of the study may not have generalizability.

Pitfalls and Cautions



- Confounding occurs when there is a factor that is related to the independent and dependent variables and thus affects the outcomes of the study.
- Bias is any error in the study design, orchestration or analysis that results in an error of inference.
- Early involvement with a statistician is recommended for those without formal epidemiologic training.
- The most interesting and novel of findings will not have any clinical impact if they are not disseminated and ultimately published.

CHAPTER 11 Clinical Research in Dermatologic Surgery

INTRODUCTION

Clinical research is defined as patient-oriented investigation conducted with human subjects aimed at advancing medical knowledge to benefit human health.¹ It is a broad, umbrella term that encompasses many types of scientific investigation including clinical trials as well as epidemiologic, behavioral, outcomes, or health services research. The central tenet of clinical research is answering a concrete, researchable question that addresses an uncertainty that the investigator wants to resolve. Dermatologic surgeons are aptly positioned to contribute significant developments in clinical research, as numerous uncertainties are encountered in daily clinical practice, and many clinical decisions are lacking a strong evidence base.

The proliferation of electronic medical records (EMRs) can allow dermatologic surgeons access to large patient databases containing key variables that enable observational clinical research and serve as a recruitment tool for interventional studies, such as clinical trials. Evidence-based clinical decision making has the potential to impact clinical care, the patient experience, and healthcare policy. The demand for minimally invasive cosmetic dermatologic procedures has also continued to trend upwards with much room for clinical research on developing and optimizing treatments.² Furthermore, recent advancements in procedural dermatology technology and techniques mandate the establishment of clinical endpoints

and continued outcome assessment, particularly patient-oriented outcomes, such as patient satisfaction and skin-related quality of life.

FORMULATING A CLINICAL RESEARCH HYPOTHESIS

The foundation of any clinical research project is a clinically significant and impactful research question. The best research questions arise from unresolved uncertainties encountered in daily practice. Clinical experience and scholarship within the field of study are both necessary for developing an informed research question. The challenge lies in transforming the clinical research question into a research hypothesis, which will guide the study protocol. The research hypothesis should be concrete and focused. For example, consider an otherwise-healthy 43-year-old male who is referred to your practice for excision of an incompletely removed nevus with moderate cytologic atypia, who inquires about the malignant potential of the nevus if left untreated. A clinical research question would be “What is the lifetime malignant potential of an untreated moderately atypical nevus in an otherwise healthy 43-year-old male?” However, answering that clinical research question would require a long-term natural history study, which would be difficult to perform and may require resources that extend beyond the scope available to the investigator. Instead the clinical research question needs to be transformed into a more well-defined, focused clinical research hypothesis question, such as “Is the 5-year risk of melanoma arising in untreated moderately atypical nevi higher than de novo melanoma in a population of patients with surgically treated moderately atypical nevi?” The later example focuses on a time period and a specific population, and is a feasible, clinically relevant question, the results of which can be extrapolated to answer the clinical research question.

HIGHLIGHTING THE KNOWLEDGE GAP: BACKGROUND AND SIGNIFICANCE

A thorough review of the literature surrounding the clinical research hypothesis is necessary to establish the context of the work and to give it

meaning. An extensive query of biomedical literature sources helps fine-tune the knowledge gap your research hypothesis aims to fill and ensures that the hypothesis or the approach to addressing it is novel. Table 11-1 outlines examples of sources of information available when using the National Library of Medicine's Gateway Web-Based System. Literature review can be performed using Pubmed for journal articles (<http://www.ncbi.nlm.nih.gov/pubmed>), Cochrane Database for systematic reviews (<http://www.cochrane.org>), and the National Library of Medicine Gateway (<https://gateway.nlm.nih.gov/gw/Cmd>). Medical librarians are also an excellent resource for guiding comprehensive literature searches.

Table 11-1. Sources of information when using the National Library of Medicine's Gateway web

Category	Collection	Data Type
Journal citations	MEDLINE/PubMed	Journal citations, 1966 to present
	OLDMEDLINE	Journal citations, 1953 to 1965
Books/serials/AVs	LOCATORplus	Catalog records for books, serials, AV materials
Consumer health	MEDLINEplus	Health information from NIH and other sources
	Health Topics	Generic and brand name drug information
	MEDLINEplus	Articles about diseases, tests, symptoms, injuries, and surgeries
	Drug Information	Information about clinical research studies
	MEDLINEplus	Directory of health organizations
	Medical Encyclopedia ClinicalTrials.gov DIRLINE	
Meeting	Meeting abstracts	Meeting abstracts on selected subjects
Other	HSRProj	Health services research projects in progress

A systematic method for organizing and archiving the literature search is essential. Services such as Endnote, Refworks, or free online resources such as Mendeley, Zotero, and F1000 Workspace can assist with organizing the initial data and can also help with the formation of a bibliography for a grant or a manuscript. Summarizing the results of a literature search in the form of a table, which includes the citation, the number of patients studied, study design, findings, and potential limitations can be very useful in honing the knowledge gap in the field, and serve as a useful tool for the research team.

DEVELOPING THE PROTOCOL

After defining the research hypothesis and highlighting the knowledge gap the work is poised to address, the next step is establishing specific components of the protocol methodology, such as the study design, the study population,

the variables of interest, and the statistical approach. A study protocol is the written plan for the clinical research study. The protocol enables organization of the research so that the project can be easily communicated to potential collaborators and funding agencies. No one approach is always the best, and each research hypothesis requires judgment about which study design, variables, and statistical methods are the most efficient in addressing the hypothesis. The following sections are aimed at improving the understanding of each of the elements of a research protocol.

Study design

There are two main classifications of study designs: one where the investigator takes a passive role in observing events (observational study) and the other where the investigator applies an intervention and examines its effects (interventional study). The randomized controlled trial is often regarded as the gold standard for establishing causality, but there are also many situations where an observations study may be a better choice (e.g., in studying rare outcomes of interest). The main limitations of observational studies are issues of bias and confounding. Confounding occurs when there is a factor that is related to the independent and dependent variables and thus affects the outcomes of the study. For instance, those who use tanning beds may participate in other high-risk activities such as drinking, smoking, or poor eating habits, all possible confounders that must be accounted for. Approaches to controlling for confounding include individual or group matching and stratification or adjustment during data analysis. Bias is any error in the study design, orchestration, or analysis that results in an error of inference. Selection, interviewer, recall, and performance bias are all common examples. An overview of study designs and considerations for when to choose the most appropriate design is presented below.

Observational studies

An observational study may be either descriptive, for example, where distributions of a disease or an exposure are described (e.g., describing trends in basal cell carcinoma incidence³), or analytic, where associations between predictors and outcomes are examined. Analytic studies are designed to test a hypothesis. Analytical observational studies can be of three

types, depending on the time sequence and sampling procedures used to collect data: case-control, cross-sectional, and cohort studies (Table 11-2).

Table 11-2. Observational Study Methods

Observational Study	Other Names	Cases	Control	Outcome	Measure
Case-control	Retrospective study	Diseased (at time of study start)	Not diseased (at time of study start), may be matched or not	% Exposed (retrospective data)	OR
Prospective cohort	Concurrent cohort, longitudinal study or prospective study	Exposed (time of study start or in the future)	Not exposed (time of study start or in the future)	Incidence rate or mortality of disease (time in the future)	RR, HR, OR, SIR, SMR
Retrospective cohort	Historical cohort study	Exposed (determined from past records)	Not exposed (determined from past records)	Incidence rate or mortality of disease (at time study has begun or outcome may be in future)	RR, HR, OR, SIR, SMR
Cross-sectional	Prevalence survey	Exposed or diseased (at time of study start)	Not exposed or not diseased (at time of study start)	Prevalence of disease	OR or relative prevalence

Case-control study. A case-control study is a retrospective observational design that observes patients who have been diagnosed with a specific disease or outcome compared to control patients, and examines the association with a certain exposure (Fig. 11-1A). Outcomes are reported as odds ratio (OR), which is defined as the odds of having a disease if you have a specific exposure. For example, a study examining patients with squamous cell carcinoma (SCC, cases) compared to those without SCC (controls) showed that those with SCC had a fourfold higher risk of having had a family history of SCC.⁴ These data were derived via questionnaires, and like most retrospective studies that utilize patient recall, are subject to recall bias as well as confounding by unmeasured variables (in this particular case, shared familial environmental exposures, such as family beach vacations)

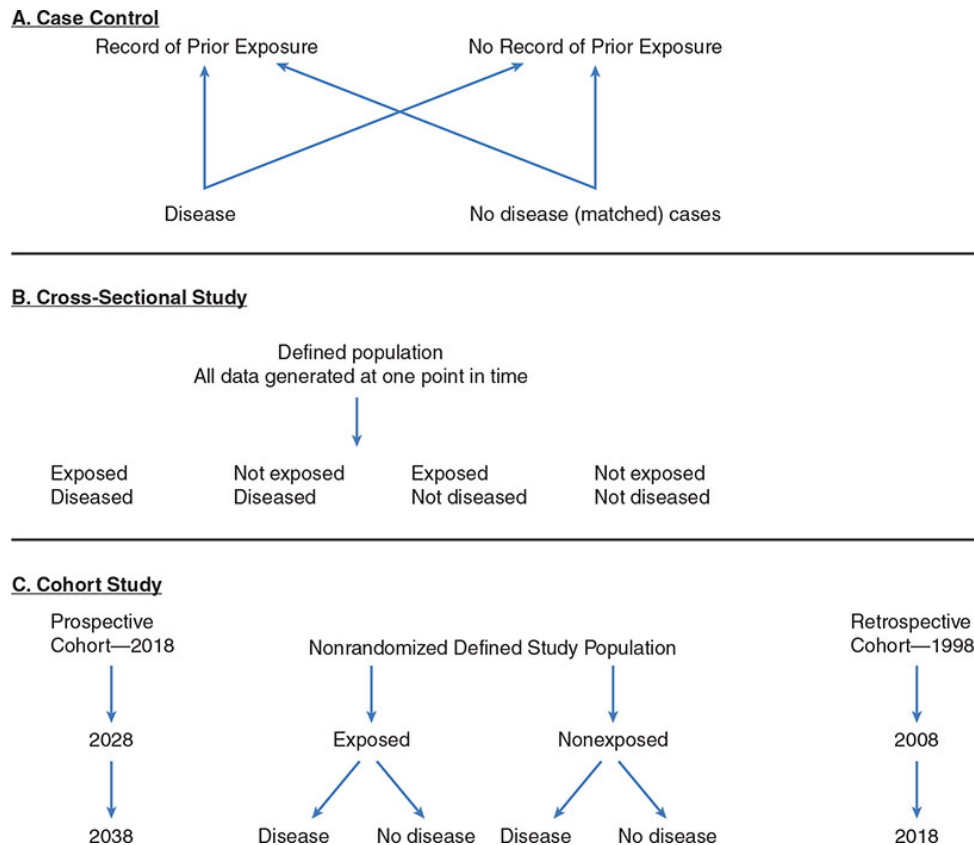


Figure 11-1. A. Case-control study model. B. Cross-sectional study model. C. Prospective vs. retrospective cohort studies.

Cross-sectional study. A cross-sectional study examines a population in a given timeframe and provides information regarding the prevalence of disease in subjects that have a given exposure compared to the prevalence of disease in subjects that have not had the exposure (Fig. 11-1B). An example relevant to dermatologic surgery is a cross-sectional study that demonstrates an association between the location of an atypical melanocytic proliferation on the head and neck, and positive margins after excision.⁵ Because the exposure and the outcome are determined at the same time, it is not possible to determine temporal relationships between the two.

Cohort study. A cohort study follows a group of individuals with a common disease or exposure over time (Fig. 11-1C). The investigator selects a group of patients that have already been exposed to a treatment or procedure and compares an outcome of interest to an exposed group. There are two forms of cohort study: prospective and retrospective. A prospective cohort is one where the participant is exposed to the variable at a time when

the study begins or in the future, and then is followed into the future to determine outcomes. A prospective cohort study is useful for determining potential causes of a condition, and is best suited for common conditions, or within a targeted population for rare conditions. Examples of prospective cohorts include the Health Professionals Follow-Up Study (HPFS) and the Nursing Health Study (NHS), who were followed prospectively from 1984 to 2008 and studies of those with a history of NMSC were found to have significantly higher risk of other primary cancers.⁶ Relative risk (RR) is defined as the risk of developing one condition if the exposure is present relative to the risk of another group without exposure. An RR of 1 implies there is no difference between groups, greater than 1 implies that the condition is more common in the experimental group, and an RR less than 1 suggests that the condition is less likely in the experimental group. RR, unlike OR, demonstrates temporality.

In contrast to a prospective cohort study, a retrospective cohort study identifies individuals that had exposure in past (typically via chart review or databases) and measures outcomes at some defined time (such as study start time or a time in the future) (Fig. 11-1). Outcomes for both can be measured in RR, hazard ratio (HR), OR, standardized incidence ratio (SIR), or standardized mortality ratio (SMR).

SIR is used to determine whether incidence of disease in a small population is high or low, while SMR is a similar measure for incidence of death. For example, a retrospective cohort study design was used to examine the association between histopathologic risk factors (poor differentiation, perineural invasion, tumor diameter ≥ 2 cm, invasion beyond subcutaneous fat) and outcomes including death and nodal metastasis from 256 high-risk cutaneous SCCs.⁷ The benefit of a retrospective cohort study is that it can be conducted on a smaller scale requiring less time and resources to complete, can more easily examine multiple outcomes, as well as rare outcomes. Depending on the research question, a retrospective cohort study design may be a good approach for dermatologic surgeons performing clinical research.

Interventional studies

Clinical trials. In a randomized controlled trial, the design is experimental; the researcher has a hypothesis and participants are randomly assigned to receive an intervention versus a placebo control (whenever ethically

possible). Blinding refers to whether the participant has been blinded to his or her assigned group. A double-blind study refers to one in which both the participants and the researchers are blinded to group assignment.

The outcomes and safety measured depend on the phase of the trial. Phase I trials are early, typically unblinded, and may or may not include a control. These are simply a test of the tolerability and safety of the intervention in order to determine whether the intervention is appropriate to study further. An example of a phase I trial relevant to dermatologic surgery is the study of vismodegib, a small-molecule inhibitor of smoothened (SMO) in the Hedgehog signaling pathway, for the treatment of advanced basal cell carcinoma.⁸ These studies may investigate the pharmacokinetics of a drug and may provide guidance for dosing during a phase II trial. A phase II study is a small controlled study where both effect and safety of intervention are measured. An example of a phase II clinical trial in dermatologic surgery involved 601 patients with superficial BCC by biopsy randomized to treatment with MAL-PDT, 5-fluorouracil, or imiquimod.⁹ A phase III study is similar to a phase II study, only larger. If the intervention passes through a phase III trial, then it is possible to gain FDA approval. For example, a phase III, double-blind, randomized controlled trial was used to examine the effect of oral nicotinamide (the amide of vitamin B3) on the rate of new nonmelanoma skin cancers over a 12-month period.¹⁰ Phase IV trials are utilized after the intervention has been out on market to monitor for adverse effects and define other applications for the intervention.

All of these study examples adhere to the Consolidation Standards of Reporting Trials (CONSORT) guidelines (<http://www.consort-statement.org/>). This group offers a 25-point checklist to follow for reporting results from a clinical trial as well as a flow diagram for an example of how to report enrollment. The checklist covers all steps from study objectives, study design, to statistical analysis.

Also, prior to submission, clinical trials that have one or more sites in the United States or that test a drug or device that is manufactured in the United States or its territories must be registered with ClinicalTrials.Gov. (<http://www.clinicaltrials.gov>). International trials can be registered on the Current Controlled Trials website (<http://www.controlled-trials.com>), which is recognized by the World Health Organization. A skin-specific resource for therapeutic trials is the Cochrane Skin Group Ongoing Trials Register

(<http://www.nottingham.ac.uk/ongoingskintrials/>), aimed at informing the community of skin-specific therapeutic trials.

Quasi-experimental designs. In addition to clinical trials, variations on the randomized controlled trial interventional study design may increase the feasibility and efficiency of the study. For example, matched pair randomization design allows for subjects with baseline confounding variables to be balanced, while one member of the pair receives the intervention. Crossover designs involve switching the placebo and intervention groups during the study to account for confounding variables, assuming there is no lasting effect of the intervention.

Secondary data analysis: meta-analysis, systematic reviews

In clinical research, systematic reviews and meta-analyses represent the highest level of clinical evidence, as they are comprised of a compilation of randomized controlled or clinical trials (RCTs). Claims of the best treatment practices within dermatologic surgery are often based upon results from systematic reviews and meta-analyses. The simultaneous analysis of numerous RCTs helps to create a consensus answer for questions in dermatologic surgery. For example, a systematic review on the treatment of squamous cell skin cancer may include RCTs examining endpoints such as cure rates, recurrence, aesthetic and functional outcomes, or cost effectiveness in order to elucidate the best treatment. Results of systematic reviews are presented as streamlined and objective appraisals allowing the clinician to identify any potential biases.

Statistical tests may be used to mitigate heterogeneity of studies reviewed and assess potential bias in the small studies included. Methodological quality of included studies may be assessed using the Strengthening of Reporting of Observational studies in Epidemiology (STROBE) checklist.¹¹

Study population

The investigator must specify demographic characteristics of the target population that will practically address the research question. Establishing geographic and temporal criteria ensures that the sample is representative and that the study is feasible. Optimizing feasibility may also involve ensuring the reliable identification of the study population, as well as

sufficient sample size. A larger sample size can yield more accurate results but must be balanced by the associated costs of data acquisition and analysis. The sample size should be adequate to convey reproducible outcomes and have adequate power.

In the case where a dermatologic surgeon is evaluating the efficacy of a novel topical treatment for actinic keratoses, inclusion criteria may involve a dermatologic disease state, such as patients with a history of actinic keratoses, or may involve a more general demographic state, such as patients who are 18 years or older, obese patients, or patients with a history of tanning bed use. Determining the inclusion criteria is a balancing act; it must be broad enough to include enough subjects to impart sufficient power to the study, while staying focused to answer the specific research question. In amassing of articles for a systematic review, selection of specific search terms and an inclusion time frame of published date may represent inclusion criteria for abstracts to analyze.

Exclusion criteria may clarify the scope of a research project. Exclusion criteria may represent patient characteristics (excluding those with a history of melanoma), disease characteristics (excluding superficial type basal cell carcinomas), or study specific (exclusion of articles written in non-English languages for a systematic review).

In some cases, rigorous inclusion and exclusion criteria may select for ideal patients that fail to reflect a general population. Thus, the results of the study may not have generalizability. For instance, a trial for a targeted drug therapy for SCC may exclude patients with comorbidities, immunosuppression, or cancer. While this may help with study outcomes and decrease drop out, the average patient with SCC will have one or more of these conditions, and thus the data may not be generalizable to the general skin cancer population.

Inclusion and exclusion criteria apply to both intervention and control groups. Control groups are important in observational and interventional studies as their presence permits a clinical comparison. Without comparing a new suturing technique with the standard of care, superiority cannot be demonstrated. Matching control and intervention groups mitigate confounding. For example, having no significant difference in age, gender distribution, socioeconomic status, or baseline health status between control and intervention groups ensures that other disease processes or social determinants of health are not driving the observed difference.

Sources of electronic data available in databases and patient registries useful for identifying a study population for clinical research in dermatologic surgery are outlined in Tables 11-3 and 11-4.¹²

Table 11-3. Databases with Utility for Dermatologic Surgeons

Clinical Trials	—NASCET Study Source of precise clinical data for risk adjustment —ACAS Study and outcomes. Limited by number and types of patients, data selected for study
Prospective	—APACHE Prospective data collection, clinically precise
Observational	—MPM data, limited by biases, variables not collected, Cohorts correlation with underlying population
Registries	—SEER Prospective collection of data of patients with —UNOS specific conditions, rich clinical information, —STS patient-specific or grouped data
Administrative Databases	—Medical Record Hospital medical (electronic) record departments —Departmental quality assurance dataset
Enrollment	—Medicare Total number of eligible persons for medical beneficiary file services —State medical Source of denominator for population-based rates research file
Encounter	—National Hospital Track utilization and resource consumption, Discharge Survey describes clinical events with ICD-9-CM —VA EDR (admissions, procedures), very large sample sizes. —State Hospital May be linked to enrollment to determine rates.
Discharge Databases	—HEDIS Encounter data enriched with specific clinical survey —UHC variables, often used for benchmarking, dataset —PHC4 CABG patient-centered information

Table 11-4. Selected Websites for Databases and Registries

State/Local Clinical and Disease-Related Databases Acuity Index Method (AIM); Iameter, Inc.: http://www.iameter.com/iameterProducts.htm APACHE/IMPACT (Cerner Corporation): http://www.cerner.com/products/products_4a.asp?id=2694 Maryland Hospital Association Quality Indicator Project: http://www.qiproject.org/ Mayo Clinic Patient Database: http://www.mayo.edu/ MediQual Dataset: http://www.mediqual.com/ Michigan Health and Hospital Association: http://www.mhaservicecorp.com/	Registries and Surveillance Databases Autologous Blood and Marrow Transplant Registry (ABMTR): http://www.ibmtr.org/ International Bone Marrow Transplant Registry (IBMTR): http://www.ibmtr.org/ National Cancer Database (NCDB): http://www.facs.org/cancer/ncdb/index.html National Program of Cancer Registries (NPCR): http://www.cdc.gov/cancer/npcr/ North American Association of Central Cancer Registries (NAACCR): http://www.naacr.org/ Scientific Registry of Transplant Registrants: http://www.ustransplant.org/index.php Surveillance, Epidemiology, and End Results: http://seer.cancer.gov/
Population Health-Based Statistics Blue Cross Blue Shield of Michigan (BCBSM) Foundation: http://www.bcbsm.com/foundation/gp_iip.shtml Centers for Disease Control and Prevention CDC Wonder: http://wonder.cdc.gov/ Centers for Medicare and Medicaid Services (CMS): Medicaid http://www.cms.hhs.gov/medicaid/ CHAMPUS (Civilian Health and Medical Program of the Uniformed Services) Database: http://www.tricare.osd.mil/training/tmart/index.cfm?fx=cmis	ICD-9 Classifications http://www.cdc.gov/nchs/icd9.htm Framingham Longitudinal Study: http://www.nhlbi.nih.gov/about/ Framingham/index.html Healthcare Cost and Utilization Project: http://www.ahrq.gov/data/hcup/ Henry J Kaiser Family Foundation: http://www.statehealthfacts.org/

Variables of interest

The endpoint or outcome of a study is the dependent variable that answers the specific research question. Outcomes may be in the form of a surgical result (e.g., clear resection margins), a disease state (e.g., melanoma), or survival (e.g., mortality from melanoma). When a study design is

longitudinal, it is important to define the window of time in which the outcomes of interest can occur. For example, it may take decades for a patient to develop a recurrence of basal cell carcinoma after excision, though defining the endpoint of recurrence within the confined time period of 5 years may be necessary for project feasibility.

Co-variables, or independent variables, are factors that may impact the endpoint or outcomes studied, and are important sources of potential bias or confounding, and need careful consideration. They may be demographic factors (age, gender, education level, and geographic location), comorbidities (immunosuppression, autoimmune disorder), or exposures (tanning bed use, occupational exposures). Co-variables may be matched between intervention and control groups in order to elucidate whether these variables represent selection bias in a particular group.

Statistical methodology

Understanding basic statistical concepts and tools can help reduce bias from potential confounding variables and improve understanding of the application of clinical findings. Statistical analysis can be performed using one of many analysis sources (SAS, STATA), the use of which is beyond the scope of this chapter. Quantitative data are those that will be collected in most observational and experimental studies. Continuous data are measured in real numbers with intermediate values (such as a height of 62.5 cm). Discrete data are those that are real numbers without intermediate values (number of family members with a history of skin cancer).

There are various ways to identify the center of the data. Mean is the average value of the data, including the outliers, which may greatly skew the mean. The median is the value directly in the middle (or the 50th percentile) of all the data points numbered from the lowest to the highest. Outliers do not significantly affect the median. The mode is the most common value in the data-set (or the peak of a histogram). The spread of data values can be described by variance, which is the average of the squared difference between a data point and the mean. Standard deviation is the square root of the variance, and measures how close data falls from the mean. For instance, a low standard deviation means most values fall close to the mean, while a high standard deviation suggests data falls over a wide range of values. Most data will fall in a bell-shaped curve in a normal (or Gaussian) distribution.

This assumes that 68% of data will fall within one standard deviation on either side of the mean, 95% will fall within two standard deviations of the mean, and 99.7% of data points will be within three standard deviations of the mean.

The p -value is a measure of the likelihood that the result could be seen by chance. Overall, a p -value <0.05 , or less than 5%, is considered the threshold for being statistically significant; however, the lower the p -value, the more likely the result is to be true. Power reflects the number of data points or study participants needed in the study to reveal a statistically significant ($p < 0.05$) difference in outcomes between two groups. As the power increases, there is less likelihood of a false negative result since the power is 1 minus the false negative rate. In general, power $>80\%$ is considered to be statistically powerful. Prior to initiating a study, a power analysis should be performed in order to determine the minimal number of data points required to reveal a significant result. The basic information needed to calculate the sample size includes the test type (one- or two-sided), significance level (usually 0.05), desired power (1- β , or type II error, usually 0.8), and effect size estimate (an estimate of group differences based on prior clinical studies or experience). Statisticians, statistical software, and online power calculators may be used to generate sample size numbers. Without this analysis, there may be too few data points to reach an accurate conclusion, or there may be far too many participants enrolled, which poses an ethical hazard of putting patients in unnecessary harm.

Parametric tests are those used to compare means when the data are normally distributed. The most well-known parametric test is a t -test, which can be applied to continuous data with a normal distribution. The t -test used will depend on whether the groups have equal or unequal variances. A paired t -test may be used when samples are correlated, for instance, in a before-and-after study or when samples are matched pairs such as in a case-control study. Nonparametric tests are those that are used when the data-set is not normal and include the Wilcoxon Mann–Whitney U -test, Kruskal–Wallis (H) test, and Wilcoxon Signed-Rank test. A chi-squared test can be used when comparing an observed proportion compared to an expected proportion, such as comparing the incidence of nodular melanomas between sexes when compared to the expected value (50:50).

A regression analysis allows the researcher to test the effects of multiple independent variables on a given outcome. For instance, instead of simply

determining the effect of age on metastatic rate of SCC, regression analysis could determine the effect of age, immune status, therapy received, and comorbidities on the metastatic rate of SCC in that study group. Regression analysis is performed using a statistical package that models the data resulting in an r^2 -value. This value can help the reader or researcher determine how much of the variance in the outcome is due to the variables identified. For instance, if $r^2 = 0.78$, 78% of the outcome is due to the defined variables.

Logistic regression seeks to model the probability of an event occurring when the dependent variable is binary and generates an OR and p -value for any given independent variable.

TEAM-BASED APPROACH TO CLINICAL RESEARCH

Key collaborators, both in the field and in outside disciplines, may significantly help inform the research project due to their knowledge, experience, or expertise. Depending on the institution or facility, teams of researchers or other ancillary staff may be available to help in the planning process and funding. Participating in a lab-based research meeting dedicated to clinical research or presenting preliminary protocols in a lecture format can yield valuable feedback and allow for refinement of the research plan or grant application. Additionally, at many large institutions, there are networks dedicated to assisting researchers through the planning and funding process. Mentorship in dermatologic research has been associated with improved productivity and success in the form of securing grants and accepted publications.^{13,14} It may be necessary to obtain assistance from a programmer or analyst to help set up a database needed to store and analyze the study data. A project coordinator can be critical in keeping projects organized, enrollment, consent process, and Institutional Review Board (IRB) submissions. Additionally, early involvement with a statistician is recommended for those without formal epidemiologic training.

ADDITIONAL TRAINING IN CLINICAL RESEARCH METHODS

Additional preparation for undertaking clinical research in dermatologic surgery includes refining skills in areas such as study design and biostatistics. Gathering data may be time consuming, but how that data are analyzed is of paramount importance in obtaining a meaningful assessment of the outcome in question. Although it is important to be familiar with basic aspects of statistics, the utility of collaborating with a statistician or quantitative analysis, even at formative stages of the research process, cannot be understated. Statisticians are experts at determining the important aspects of the research plan, such as appropriate sample size, and open discussions of project methodology allow for feedback from a statistician in addition to suitable analysis of data. Garnering a knowledge base in these disciplines will aid the clinical researcher in facilitating collaboration with statisticians within a research team. There are numerous online resources available to help bolster knowledge of basic quantitative methods, such as the free online course offered by Harvard University's edX program entitled "Health in Numbers: Quantitative Methods in Clinical & Public Health Research" (<https://www.edx.org/course/health-numbers-quantitative-methods-harvardx-ph207x>). In addition, many institutions offer intensive short courses in biostatistics for fellows and physicians.¹⁵ Particular institutions may offer grant preparatory courses and offer feedback in a structured setting.

FUNDING AND BUDGETING

Whether a physician–scientist in dermatologic surgery dedicates the majority or a small portion of his or her career to clinical research, funding allows for increased sustainability. After a study protocol has been developed, the investigator drafts a proposal, which concisely communicates a logical outline of the study plan, and showcases the merits of the study. Senior colleagues serve as a resource for choosing a specific funding agency. The range of granting agencies for biomedical research includes governmental agencies, foundations, manufacturers of drugs and devices, professional societies, and patient advocacy groups. A list of all current US government discretionary funding opportunities can be found on the website [grants.gov](https://www.grants.gov).

Table 11-5 outlines some of the available funding opportunities for dermatologic surgeons pursuing clinical research. Affiliation with an academic institution, industry, or a professional society may afford additional access to funding sources.

Table 11-5. Funding Mechanisms for Dermatologic Surgeons Engaged in Clinical Research

Funding Category	Sources
Nongovernmental	Dermatology Foundation Skin Cancer Foundation American Skin Association
Governmental	National Institutes of Health
	Award
	F32: Individual post-doctoral fellowship
	K01: Mentored Research Scientist Award K02: Independent Research Scientist Development Award K05: Senior Research Scientist Award K07: Academic Career Development Award K08: Mentored Clinical Scientist Research Career Development Award K12: Clinical Scientist Institutional Career Development Program Award (Appointee) K22: Career Transition Award K23: Mentored Patient-Oriented Research Career Development Award K43: Emerging Global Leader Award K76: Emerging Leaders Career Development Award K99/R00: Pathway to Independence Award
	Target Recipient Career Level
	Post-Doctoral Training
	Early Career
	Mid-Career
	Established Investigator
	R01: Research Project Grant Program R03: Small Grant Program R15: Academic Research Enhancement Award R21: Exploratory/Developmental Research Grant
	Agency for Health Quality and Research Centers for Disease Control Department of Defense Department of Energy—Office of Science Department of Veteran Affairs National Science Foundation Office of National Drug Control Policy
Professional Society	American Society of Dermatologic Surgeons American Academy of Dermatology Society for Investigative Dermatology Women's Dermatologic Society

In addition to securing funding, establishing a budget for direct and indirect costs will help guide the plan and scope of the clinical research project. Budgeting allows for control and awareness of how funding is allocated, and establishing a budget facilitates future communication with collaborators and potential funding sources. Aspects of a clinical research budget include personnel, consultant costs, equipment, supplies, travel, patient care costs, and consortium and contractual costs. An example budget form is provided in Table 11-6; however, often specific grants will require a unique budget form.

Table 11-6. Simplified Budget Example

Expense Description	Project Role	Budgeted Funds	Percent of Total
Key personnel			
Other personnel			
Total PERSONNEL COSTS			
Equipment			
Other direct costs (i.e., travel, office supplies, IT equipment, operating costs)			
Facilities and administrative costs (indirect costs)			
Total costs			

Dermatologic surgery is unique in that many innovations stem from physician–scientists with loose or even no formal academic affiliations. In many cases, such investigations may be self-funded.

PROTECTION OF HUMAN SUBJECTS

Human subjects training

The clinical researcher has an obligation to protect the privacy and safety of subjects. The Health Insurance Portability and Accountability Act (HIPAA) of 1996 provides nationwide privacy protection for health information in the United States. The regulations set boundaries for the use of health records and all research-involving human participants is subject to review by the IRB. When enrolling in a study, patients must be told the purpose of the study, the risks and benefits, alternatives to participate, and his or her rights of confidentiality and right to withdraw from the study at any time. Each subject must provide voluntary agreement to participate by signing informed consent. Training on regulations for human subject research is available online through the Collaborative Institutional Training Initiative (CITI).

The role of the Institutional Review Board

Any research proposal that involves the use of human subjects has to be approved by an IRB. The role of the IRB is specifically stated in federal regulations regarding human research (Code of Federal Regulations, Volume 21). By law, the IRB must review all components of the research project and ensure that the following requirements are met before approving any study:

- Minimization of risks to subjects
- Assessment of risks to ensure that the risk/benefit ratio is reasonable—It is important to bear in mind that this assessment is limited to the risks and benefits for the subjects in the study, as opposed to society in general
- Equitable selection of subjects
- Overview of the informed consent process (including documentation) and assurance that consent will be obtained from all subjects, as appropriate
- Data monitoring, if appropriate, to ensure the subject's safety
- Protection of subject's privacy
- Protection of special populations who may be vulnerable to coercion (e.g., children, pregnant women, prisoners, handicapped, mentally disabled or educationally or economically disadvantaged people), if appropriate.

Finally, the IRB approval to conduct a specific research project must be updated with changes to the study protocol, and must be renewed.

For patients involved in the study, compliance with the HIPAA is necessary and informed consent is a prerequisite.

DISSEMINATING FINDINGS

The most interesting and novel of findings will not have any clinical impact if they are not disseminated and ultimately published. When choosing a journal for submission, it is important to consider the scope of the journal, its target audience, and the impact factor of the journal. It is important to look at a journal's website to make sure your paper fits in with the scope and mission. If you are not personally familiar with the journal, it is important to read recent issues to understand the types of papers that the journal and editorial board select for publication. Typically journals offer publishing guidelines for various article types and will also offer guidance for how to respond to reviewer comments. Additionally, there are published reporting criteria for the various epidemiologic formats ([Table 11-7](#)). Despite a well-planned and executed study, rejection is always a possibility and researchers should be prepared to revise the manuscript and resubmit until the proper audience is reached. There are resources that can help guide dermatologic

surgeons on approaches to addressing peer-review comments that maximize the chance of subsequent publication.^{16,17}

Table 11-7. Reporting Criteria for Various Study Types and Corresponding Websites

Study Type	Reporting Criteria	Website
Randomized trials	CONSORT	http://www.consort-statement.org/downloads
Animal preclinical studies	ARRIVE	http://www.nc3rs.org.uk/arrive-guidelines
Quality improvement	SQUIRE	http://www.squire-statement.org/index.cfm?fuseaction=page.viewPage&pageID=471
Observational	STROBE	http://www.strobe-statement.org/index.php?id=available-checklists
Systematic Reviews	PRISMA	http://www.prisma-statement.org/PRISMAStatement/Default.aspx
Case Reports	CARE	http://www.care-statement.org/
Qualitative Research	SRQR, COREQ	http://intqhc.oxfordjournals.org/content/19/6/349.long
Diagnostic/prognostic studies	STARD, TRIPOD	https://www.tripod-statement.org/TRIPOD/TRIPOD-Checklists/TRIPOD-Checklist-Prediction-Model-Development-and-Validation
Economic Evaluations	CHEERS	http://www.ispor.org/Health-Economic-Evaluation-Publication-CHEERS-Guidelines.asp
Study Protocols	SPIRIT, PRISMA-P	http://www.spirit-statement.org/publications-downloads/

CONCLUSIONS

Many methods exist for examining important clinical questions in the field of dermatologic surgery. It is important to choose a study design that accurately addresses the research question and develop a protocol that will generate data needed to answer the question. Available funding and collaborative opportunities will help in the pursuit of clinical research. Regardless of years in practice or practice setting, all dermatologic surgeons have the ability to confront uncertainties in clinical practice through clinical research. Many of the high-quality surgical techniques and improvements in clinical care enjoyed by dermatologic surgeons today result from clinical research physician–scientists. Advancements in clinical research in dermatologic surgery have the ability to impact clinical practice and improve the patient and surgeon experience, and all dermatologic surgeons have the potential to become active participants in this process.

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Part II

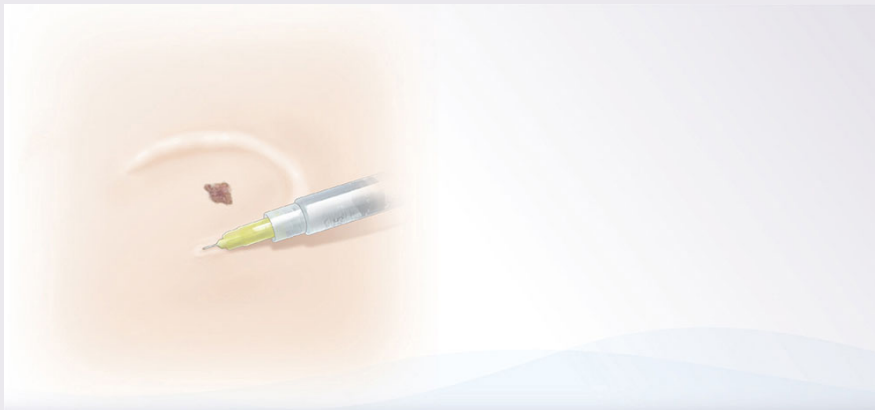
SURGICAL PROCEDURES FOR DIAGNOSIS, THERAPY, AND RECONSTRUCTION

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CHAPTER 12 Local Anesthesia, Regional Nerve Blocks, and Postoperative Pain Management

David T. Harvey
Emma Elizabeth Harvey



SUMMARY

- Local anesthesia is a critical component of dermatologic surgery, and allows even large flaps to be performed comfortably in an office setting.
- If patients unnecessarily undergo painful procedures, or painful anesthesia injection, this may adversely affect their overall experience and may undermine their confidence in the dermatologic surgeon.

Beginner Tips



- Lidocaine 1% with 1:100,000 epinephrine is the most widely used local anesthetic in dermatologic surgery.
- Lidocaine-allergic patients can usually be treated with either bupivacaine or, for small biopsies, normal saline or cryoanesthesia.
- Patients may complain of an “allergy” to epinephrine; on detailed history, this is often related to intravascular injection during a dental procedure, but patient preference should always be respected.
- Use physical and mental distraction liberally and always inject slowly when possible.

Expert Tips



- For Mohs surgery defects on the lower leg and other high-risk areas, consider adding dilute clindamycin to the local anesthetic.
- 0.15 cc of clindamycin 150 mg/mL is added to a 50-mL vial of local anesthetic. Risks, including allergy, should be discussed with the patient.

Don't Forget!



- Concerns regarding digital block-related necrosis due to the addition of epinephrine are probably unfounded, though volume should be minimized when possible.
- Patients should be warned that temporary paralysis may be seen postoperatively; a unilateral facial droop is almost always due to anesthetic effect rather than nerve damage.

Pitfalls and Cautions



- Buffering bupivacaine with sodium bicarbonate is contraindicated due to the risk of precipitation.

- Be cautious when using off-label or compounded topical anesthetics, as these may lead to systemic side effects.

Patient Education



- Topical anesthetics may be applied at home prior to the procedure, though for most patients, a slow local anesthetic injection coupled with distraction leads to only minimal discomfort.
- Local anesthesia is usually instant, while nerve blocks take several minutes to take effect.

CHAPTER 12 Local Anesthesia, Regional Nerve Blocks, and Postoperative Pain Management

INTRODUCTION

Local anesthesia is of critical importance in dermatologic surgery. Local anesthesia permits the performance of procedures virtually painlessly through inducing a reversible loss of sensation in a well-circumscribed area of the body. Local anesthetic agents lead to anesthesia by inhibiting excitation of nerve endings or by blocking conduction in peripheral nerves.¹ A thorough understanding of local anesthesia is, therefore, important to improve the surgical experience for both patient and dermatologic surgeon.

HISTORY

The biological effects of local anesthetics were first recorded in 1860, when Albert Niemann, a graduate student in pharmacology, isolated cocaine from the plant *Erythroxylum coca* and recorded the numbing sensation felt when the substance was placed on his tongue.² Niemann did not initially consider the use of cocaine as a surgical anesthetic. Years later, in 1884, a graduate

student in Vienna named Sigmund Freud experimented with the effects of cocaine on himself and animals. Freud published a paper called “Über Coca”³ which claimed that cocaine could be used to treat mental disorders. In 1884, Karl Koller, an ophthalmology resident and colleague of Freud, presented the idea of cocaine being used clinically and issued a paper on its use in ophthalmologic surgery.² Physicians, at first, were slow to accept the idea of using cocaine for medical purposes but eventually embraced its use. This initial acceptance was followed by scrutiny once the addictive and toxic aspects of cocaine were recognized.

In the early 20th century, several safer anesthetics were developed. In 1904, Alfred Einhorn synthesized an ester of para-aminobenzoic acid (PABA) called procaine.⁴ A year later, Heinrich Braun was the first to successfully use it as an anesthetic.² Höechst initially promoted procaine under the name Novocain, but soon found that it produced an extreme drop in blood pressure and was responsible for several deaths.⁵ To overcome this, procaine was combined with epinephrine. In 1930, a more potent PABA ester, tetracaine, was introduced⁵; unfortunately, it demonstrated a proclivity to produce allergic reactions. In 1943, Lofgren and Lundqvist^{2,4} synthesized an amide derivative of diethylaminoacetic acid called lidocaine that proved to be effective and safe.⁶ This eventually led to its mainstream use in surgery as a local anesthetic. Since the initial introduction of lidocaine, several other local-acting drugs have been developed.

STRUCTURE

All local anesthetics have similar structures and contain three parts: the aromatic ring, the intermediate chain, and the terminal amine portion (Fig. 12-1). Any alterations of the anesthetic agent can affect its pharmacological properties. The aromatic ring, a lipophobic component, is responsible for the diffusion of the anesthetic through cell membranes and nerve sheaths.⁶ The intermediate chain binds either an ester or an amide containing between three and seven carbon equivalents, and is responsible for its mode of action.⁷ Disruption of the intermediate chain is responsible for local anesthetic metabolism and the reversible nature of these agents.⁷ The amine terminus can arise in a tertiary form that is lipid soluble or a quaternary form, which is

water soluble and positively charged.⁸ It is this same terminus that is thought to bind to the sodium channel and determine the length of action of the anesthetic.⁷

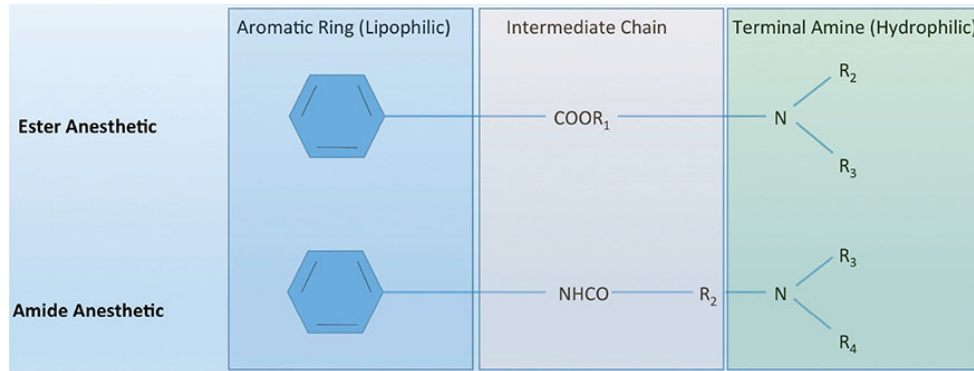


Figure 12-1. All local anesthetics have similar structures and contain three parts: the aromatic ring, the intermediate chain, and the terminal amine portion.

CLASSIFICATION

Local anesthetics have two main chemical classifications,⁵ and depend on the structure of the intermediate chain: those, which contain an amide group (e.g., lidocaine), and those which contain an ester attachment (e.g., procaine). This linkage is very important to the anesthetic agent as it defines the pathway by which the molecule is metabolized and excreted.⁶

Amide anesthetics are hepatically metabolized.^{5,6} Lidocaine is considered an intermediate potent anesthetic, and has a wide range of clinical uses.⁹ It exhibits a rapid onset of action, shows no cross reactivity to ester-type local anesthetics,⁵ and is therefore safe to use in patients who are allergic to procaine or tetracaine. Lidocaine comes in 0.5%, 1%, and 2% concentrations, and lasts on average for 30 to 400 minutes.⁶ Bupivacaine is a high-potency amide anesthetic, which lasts for 2 to 6 hours.⁶ Longer-lasting effects of bupivacaine have been attributed to its slower elimination time.¹⁰ Lidocaine and bupivacaine in combination have been studied and shown to prolong mean anesthetic duration,¹¹ as is sometimes required with longer Mohs surgery procedures. A comprehensive list of amide anesthetics is shown in Table 12-1.

Table 12-1. A Comprehensive List of Amide Anesthetics

Generic	Brand
Articaine	Septocaine®
Bupivacaine	Marcaine®, Sensorcaine®
Dibucaine	Nupercainal®
Etidocaine	Duranest®
Levobupivacaine	Chrocaine®
Lidocaine	Xylocaine®
Mepivacaine	Carbocaine®
Prilocaine	Citanest®
Ropivacaine	Naropin®
Trimecaine	Mesocain®

Ester local anesthetics are metabolized by pseudocholinesterase and excreted in the urine.^{6,8} The strength and duration of these agents correlate inversely with their rate of hydrolysis.⁶ Patients with atypical¹² or low levels of pseudocholinesterases are prone to a greater risk of inadvertent toxicity.⁶ PABA is a major metabolic product of ester anesthetics, and a main reason for contact allergies.⁸ The most common types of ester anesthetics are benzocaine, procaine, tetracaine, and cocaine.⁶ The latter is a highly effective vasoconstrictor, and has been used for nasal procedures.¹³ Procaine has a rapid onset of action but shorter half-life, lasting for 15 to 30 minutes.⁶ Tetracaine is 10 times more potent than procaine and is often used as an ocular anesthetic drop.^{14,15} Chloroprocaine was developed to meet the need for a shorter-acting anesthetic agent with a favorable safety profile.¹⁶ It is licensed in Europe for procedures lasting up to 40 minutes. Although less toxic than lidocaine, it is a more painful anesthetic to administer due to its acidic pH.¹⁴

STRUCTURE AND PHYSIOLOGY

Mechanisms of action

Local anesthetics work through reversibly impeding nerve depolarization and activation by interfering with Na^+ ion movement across nerve membranes (Fig. 12-2).¹⁷ Decreased permeability of cell membranes to Na^+ ions prevents the nerve action potential from being reached. In a resting cell, intracellular electric potential is intrinsically negative compared to the extracellular space.⁶ The nerve's cell membrane and Na/K ATPase pump help maintain this natural gradient.⁶ Although the exact mechanism of sodium channel blockade is unclear, one postulate is that local anesthetics bind to a receptor located on the cytoplasmic portion of the cell membrane.¹⁸ To reach this site, the uncharged form of the anesthetic diffuses through hydrophobic pathways.¹⁴ After binding, the anesthetic induces a conformational change in the receptor and renders it inactive.¹⁹ Local anesthetics preferentially bind to activated sodium channels in rapidly firing neurons leading to what is termed a “state-dependent” blockade.^{20,21}

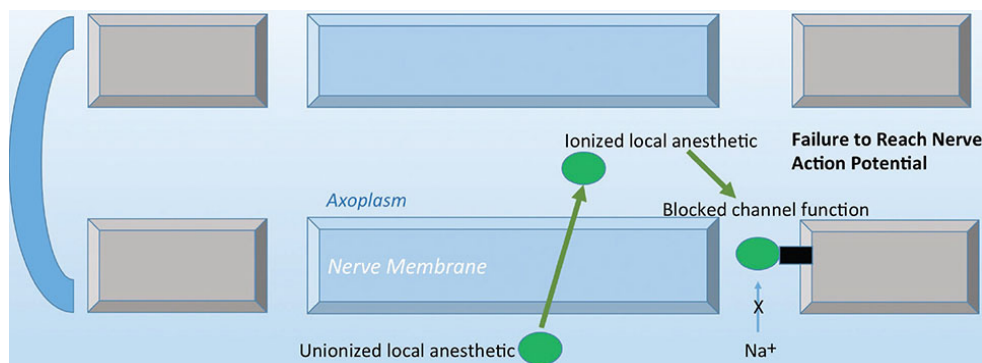


Figure 12-2. Local anesthetics work through reversibly impeding nerve depolarization and activation by interfering with Na^+ ion movement across nerve membranes.

Cutaneous nerve fibers vary in size and type.⁶ Larger myelinated nerves are usually more difficult to anesthetize than their smaller counterparts.⁵ There are three main categories of nerve fibers. They are referred to as A, B, and C (Table 12-2). Somatic fibers are divided into four subtypes: Alpha, Beta, Gamma, and Delta. All A fibers are myelinated,⁵ with Alpha being responsible for motor impulses and proprioception. Beta fibers are responsible for pressure and light touch, Gamma fibers for proprioception

and muscle spindle tone, and smaller Delta fibers for pain and temperature.^{6,14} B fibers are myelinated and are preganglionic sympathetic fibers.⁵ C fibers are the smallest nerves and are unmyelinated.⁵ They are responsible for conducting temperature and pain sensation in a manner similar to A Delta fibers.⁵ Due to their smaller size, nerves that conduct the sensation of pain and temperature are affected by local anesthesia before the loss of pressure, vibration, and proprioception.¹⁴ This is why patients may be able to detect light touch during procedures in which they are effectively numbed.^{5,14} It is important to understand this principle and be able to readily explain this to the patient, preferably prior to surgery, to reduce their anxiety.

Table 12-2. Nerve Fiber Types

A Fibers		
Alpha	(Myelinated)	Motor Impulses and Proprioception
Beta	(Myelinated)	Pressure and light touch
Gamma	(Myelinated)	Proprioception and muscle spindle tone
Delta (Small)	(Myelinated)	Pain and temperature
B Fibers		
	(Myelinated)	Preganglionic sympathetic
C Fibers (Small)		
	(Unmyelinated)	Pain and temperature

Anesthetic additives

Local anesthetic agents may come premixed or are compounded with additives for additional pharmacological benefits. It is important to understand how these additives work, what concentrations are safe, and how can they affect anesthesia efficacy.

Epinephrine

Epinephrine is the most common additive used in local anesthesia.⁶ It counters the local anesthetic's tendency to induce vascular smooth muscle relaxation, which can promote bleeding.⁵ Vasoconstrictive effects occur

quickly, with full effects taking 7 to 15 minutes.^{5,14} Epinephrine limits anesthetic diffusion and helps to minimize the absorption of anesthetic into the systemic circulation. It also allows less anesthesia to be used to complete the numbing process. A liability for epinephrine use is the potential for delayed bleeding once its effects wear off. Concerns for postoperative hematoma development¹⁴ should be addressed with the patient prior to surgery. Epinephrine is labeled as a Category C drug.

Sodium bicarbonate

Sodium bicarbonate is a weak base with the molecular formula NaHCO_3 . When mixed with lidocaine with epinephrine, resultant injections are notably less painful.^{22,23} Simple lidocaine with epinephrine has an acidic pH of 3.3 to 5.5,⁵ which contributes to patient discomfort. It is usual for dermatologic surgeons to “buffer” lidocaine with epinephrine with 8.4% solution of NaHCO_3 as follows: 1:10 (1 part 8.4% NaHCO_3 to 10 parts lidocaine 1% with 1:100,000 epinephrine) or 1:15 (1 part NaHCO_3 to 15 parts 1:200,000 epinephrine).⁵

Although patients experience less pain with buffered lidocaine, the addition of NaHCO_3 makes the compound less stable, resulting in a shorter-action duration.²⁴ On the positive side, the addition of NaHCO_3 allows for faster nerve membrane penetration and a quicker onset of anesthetic effect.⁷ In short, there is a “double-edged” sword when adding sodium bicarbonate to lidocaine, though many dermatologists utilize this additive because of a perceived greater benefit for the patient. Importantly, the use of sodium bicarbonate additives with bupivacaine is contraindicated due to the risk of agent precipitation.²⁵

Hyaluronidase

Hyaluronidase is an enzyme that breaks down hyaluronic acid,⁵ an acid mucopolysaccharide present in the dermis. When added to local anesthesia, hyaluronidase facilitates diffusion of the anesthetic through soft tissues. This results in a wider field of local anesthesia, faster onset of action, less tissue

distortion, and easier tissue undermining.²⁶ In ophthalmology, hyaluronidase additives allow the surgeon to minimize injection sites, decrease the volume of anesthesia used, and lessen the bruising risks for the patient.⁵ Doses in cutaneous surgery vary. Some authors recommend that 150 units of hyaluronidase be mixed in 20 to 30 mL of lidocaine for a concentration of 7.5 units/mL.²⁷

There are some risks with using hyaluronidase, including decreased anesthetic duration and a greater risk of toxicity due to enhanced absorption.²⁷ Hyaluronidase also contains the preservative thimerosal,⁵ which is a contact allergen. Preoperative skin testing in highly sensitive patients is recommended prior to its use.^{5,27} Hyaluronidase should also not be used in those with a documented bee venom allergy.²⁸

Triamcinolone

There are several advantages to combining lidocaine with a corticosteroid injectable.²⁹ This mixture is useful for treating acne cysts, keloid scars, and alopecia areata. Doses vary from 2.5 to 5 mg/mL for facial cysts to 20 to 40 mg/cc for thick keloid lesions. In orthopedic surgery, triamcinolone mixed with lidocaine serves as both a diagnostic and therapeutic tool to evaluate for rotator cuff tendonitis.³⁰

Clindamycin

Clindamycin mixed with lidocaine has been described as a way to provide antibiotic prophylaxis. One study examined 1172 wounds treated with 50 cc 1% lidocaine mixed with epinephrine, 5 mL of 8.4% NaHCO₃, and 0.15 mL of 150-mg/mL clindamycin.³¹ Culture-positive wound infections were less frequent in the clindamycin group compared to control group. No allergic reactions were reported. More data need to be evaluated before this combination is routinely recommended.

Cosmetic injectables

Many cosmetic injectables today come premixed with local anesthesia (Table 12-3). Several hyaluronic acid and calcium hydroxyapatite injectables are commercially prepared or mixed with 0.3% lidocaine.^{32,33} Poly L-lactic acid can be mixed with local anesthetic using 6 cc of sterile water and 3 cc of 1% lidocaine with 1:1000 epinephrine.³⁴ This allows for a more comfortable experience for the patient.³³ especially when correcting volume deficiencies in sensitive areas such as the lips, tear troughs, temples, and malar cheeks.

Table 12-3. Cosmetic Injectables Premixed with Local Anesthetic

Filler Name (Brand)	Type/Lidocaine Concentration
Juvederm Ultra®/ Ultra Plus®	Hyaluronic acid/0.3% lidocaine
Juvederm Volbella®	Hyaluronic acid/0.3% lidocaine
Radiesse (+)®	Calcium hydroxylapatite/0.3% lidocaine
Perlane®	Hyaluronic acid/0.3% lidocaine
Bellafill®	Bovine collagen/PMMA microspheres/0.3% lidocaine
Restylane Silk®/Lyft®	Hyaluronic acid/0.3% lidocaine
Prevelle Silk®	Hyaluronic acid/0.3% lidocaine

Microbotox uses multiple microdroplets of diluted onabotulinum toxin A injected into the superficial dermis.³⁵ The goal of this treatment is to improve skin texture, diminish oil production, smoothen horizontal creases, and decrease vertical banding of the neck. The Microbotox solution is mixed by adding a small volume of lidocaine and larger amount of preservative-free saline to onabotulinum toxin A, yielding a final concentration of 20 to 28 units of onabotulinum toxin A per milliliter of solution.³⁵ Approximately 100 to 120 injections are used to treat both sides of the face and neck (Fig. 12-3).

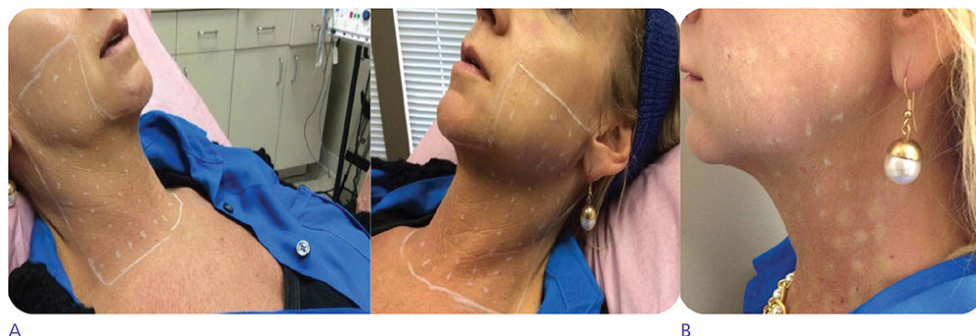


Figure 12-3. A. Approximately 100 to 120 injections are used to treat both sides of the face and neck: 100 markings total, 50 per side spaced 1.5 to 2 cm apart. B. Note skin blanching after intradermal injections is placed due to lidocaine with epinephrine. Decreased oil secretion and a smoother skin texture is noted after the Microbotox procedure.

Deoxycholic acid is a cosmetic injectable that is used to treat submental fullness.³⁶ It works through inducing focal lipolysis and serves to restore a more youthful cervicomental angle after two to five treatments. Deoxycholic acid induces some pain and swelling which lasts minutes to days post-injection. To make the procedure more comfortable, small volumes of local anesthetic, for example, 4 to 6 cc of lidocaine with 1:100,000 epinephrine can be injected into the submental area prior to deoxycholic acid treatment.³⁷

Mixing two or more anesthetics

Mixing two or more local anesthetics is a common practice for dermatologic surgeons.^{6,38} Several randomized controlled trials comparing mixtures of local anesthetics have been conducted.^{39,40} Combinations studied include bupivacaine and lidocaine, bupivacaine and mepivacaine, and prilocaine and ropivacaine. Evidence suggests that mixing these agents for local infiltration and nerve block anesthesia is safe. There is insufficient data to determine whether any combination results in a faster onset or longer duration of anesthesia, and no strong evidence supports the benefits of mixing anesthetics over the use of a single agent.²⁸

Topical anesthetics

Topical anesthetics play a major role in dermatologic surgical procedures.^{5,28,41} From laser hair removal to cosmetic injectables to minor skin surgery, topical anesthesia enhances patient comfort through allowing a “needleless approach” to patient numbing. The limitation of utilizing topical anesthetics is the ability of these agents to penetrate the stratum corneum.⁴² For this reason, they work better in thinner skin areas such as the oral mucosa⁵ and/or genital skin. Newer delivery systems have enhanced the rate of topical anesthetic absorption and effect.⁴³ A list of commonly used compounded and standardized topical anesthetics can be found in [Table 12-4](#).

Table 12-4. Commonly Used Topical Anesthetics in Dermatologic Surgery

Name (Brand)	Ingredients
EMLA™ Cream	2.5% lidocaine and 2.5% prilocaine
LMX™	4% or 5% lidocaine cream
Pliaglis™	7% lidocaine and 7% tetracaine
BLT	20% benzocaine, 6% lidocaine, 4% tetracaine
TAC	0.5% tetracaine, 1:2000 epinephrine, 11.8% cocaine
LET	4% lidocaine, 1:2000 epinephrine, 0.5% tetracaine
Amethocaine™ gel	4% tetracaine gel
Hurricane gel™	20% benzocaine
Lasergel™ ^a	10% lidocaine, 10% tetracaine
Lasergel plus 10/10 ^a	10% lidocaine, 10% tetracaine, 0.5% phenylephrine
Photocaine™ gel ^a	6% lidocaine, 6% tetracaine
Betacaine LA™ ointment ^a	15% lidocaine, 5% prilocaine, phenylephrine
Betacaine Plus™ ointment ^a	15% lidocaine, 5% prilocaine

^aReceived a warning from the U.S. Food and Drug Administration in 2005.

Modified with permission from Sobanko JF, Miller CJ, Alster TS. Topical anesthetics for dermatologic procedures: a review, *Dermatol Surg*. 2012 May;38(5):709–721.

Topical benzocaine

Benzocaine is commonly utilized to numb mucosal surfaces. This ester anesthetic is commercially available as a spray, gel, ointment, and solution, with concentrations ranging from 5% to 20%.⁵ Benzocaine has a higher risk of contact sensitization and methemoglobinemia,^{5,6} and must be used with caution. One common benzocaine product is Hurricane gel™, a 20% gel that is useful for dental procedures and prior to administering intraoral nerve blocks. The gel is applied for 30 to 60 seconds in the desired location.⁶ Effects last for up to 15 minutes. Cetacaine™ is a compound benzocaine product that contains 14% benzocaine, % butyl amino benzoate, and 2%

tetracaine. It has a rapid onset of action and has longer-lasting effects, for example, 30 to 60 minutes.^{6,13}

Topical lidocaine

Lidocaine has been used as a topical anesthetic for many years.⁴⁰ It is commercially available as a eutectic combination product or as a solitary agent, with strengths varying from 2% to 30%.⁶ Topicaine™ is a 4% lidocaine microemulsion gel,^{6,44} which has gained some popularity. It is formulated in cooling penetrating 5% lidocaine gel composed of water, ethanol, glycerin, jojoba oil, aloe vera oil, glycerol monolaurate, benzyl alcohol, carbomer 940, and EDTA.

There is support to suggest that compounded lidocaine mixtures (lidocaine/prilocaine) may have excellent efficacy for certain skin procedures.⁴⁵ Delivery systems employing microemulsion gels have been shown to be more effective in reducing pain during cutaneous surgery procedures. LMX™ is one such product. It has a fast onset of action requiring only 30 minutes of application time prior to procedures.⁶ Studies comparing LMX 5%™ to EMLA™ show that both are equally effective for pain reduction.^{46,47} One study showed that LMX 5%™ requires a shorter application time to achieve pain control.⁴⁶

Topical tetracaine

Tetracaine is an ester anesthetic, which comes in a topical cream, gel, and solution.⁵ Amethocaine™ gel is a 4% tetracaine gel that is formulated within a lecithin vehicle, which allows for increased penetration into the skin.⁵ When applied for 60 minutes, it has proved superior to other topical anesthetics. This was supported in one study that evaluated pulsed-dye-laser patients treated with Amethocaine as determined by visual and verbal rating scores.³² Combination products using tetracaine have also been effective for skin surgery procedures as noted below.

Lidocaine tetracaine peel

The lidocaine/tetracaine (LT) combination peel consists of a 1:1 eutectic mix of 7% lidocaine and 7% tetracaine.⁵ It is constituted in a membranous matrix

in which the anesthetic mixture air-dries into a flexible membrane. This membrane is then removed just prior to procedure initiation. Application times vary, but recommendations are 20 minutes for nonablative laser treatments, 30 minutes for cosmetic injectable procedures, and 60 minutes for tattoo removal.⁴⁸ The LT peel has also been shown to be effective for cryotherapy^{5,49} and CO₂ laser resurfacing.⁵⁰ Studies comparing the LT peel with placebo and EMLA cream have shown that the LT peel may be superior.^{50,51} With respect to safety, side effects are limited to local transient erythema.⁵¹ Care must be used when applying any numbing agents around the eyes.

EMLA

EMLA is a 2.5% eutectic mixture of lidocaine and prilocaine that is packaged commercially as a cream or patch.⁵ It is one of the most common topical agents used in dermatology and available via prescription. The definition of a eutectic mixture is one in which the ingredients are formulated to melt to liquid phase at room temperature.^{41,52} In addition to the two active anesthetic agents, EMLA contains emulsifiers (polyoxyethylene), thickening agents (carboxypolymethylene), and distilled water.⁵ It has been effectively used prior to laser surgery, chemical peels, graft procedures, skin biopsies, and electrosurgery procedures.^{41,43}

To work effectively, EMLA is usually applied under occlusion with either a plastic wrap or dressing.⁶ Numbing effectiveness depends, in part, on the anatomic area being treated and the duration of the occlusion. For example, on the face, anesthesia can occur in 30 minutes or less, whereas on mucous membranes it only takes 5 to 15 minutes.⁶ Most dermatologists leave EMLA on the skin for at least 1 hour and, for more painful procedures, 2 to 3 hours with occlusion.^{5,41} The maximum effect of anesthesia is reached within 2 to 3 hours after application. EMLA penetrates 3 mm into the skin after 1 hour of application and 5 mm after 2 hours.⁴¹

Like other amide anesthetics, EMLA should be used cautiously in conditions where the skin integrity is breached, such as psoriasis and eczema.⁵³ It is contraindicated in those with liver disease and amide hypersensitivity.⁵³ Care also must be taken when using EMLA around the eyes.⁵⁴

Pharmacy-compounded topical anesthetics

Topical anesthetics are in some instances compounded by pharmacies for use in dermatology. Standardization of compounded products proves difficult because individual pharmacies use different protocols to mix various ingredients in their topical anesthetics.^{55,56} Formula standardization should be considered for compounded anesthetics, since the formulations are not regulated by the FDA and may be inconsistent.⁵⁷ As compounded anesthetics do not require clinical trials, there is a great variability in use.⁵⁶ Mixtures are usually made using various concentrations of lidocaine, Betacaine, and tetracaine.^{6,56} Care must be taken when using compounded topical anesthetics and choosing the right company to manufacture them. Particulate matter has been shown in one case to cause corneal abrasions due to issues with a particular benzocaine 20%, lidocaine 6%, and tetracaine 4% (BLT) preparation.⁵⁷ It is essential that the dermatologist develops a working relationship with a reputable compounding pharmacy and not exceeds the dosages established for traditional topical and/or injectable anesthetic agents. The use of pharmacy- compounded topical anesthetics should only be performed under the direct supervision of a physician and conservatively applied to limited body areas.

Cryoanesthesia

The use of cold as an adjunct can be very helpful in reducing the pain associated with minor procedures such as cosmetic injectables, digital blocks, and wart destruction.^{5,6,58} The placement of a cold pack for 5 to 10 seconds prior to cosmetic injectables is a rapid and inexpensive way to provide the patient with increased comfort.

Cryorefrigerant provides another source of effective anesthesia by rapidly cooling the skin.^{5,6,59} They are held 6 in from the target zone and sprayed until the treatment area turns white,⁶ usually in 4 to 6 seconds. One should wear a mask and eyewear to avoid inhaling the vaporant and to protect the eyes from inadvertent contact.⁵ Ocular exposure from cryorefrigerants and even cryotherapy has been reported to cause pigmentary alterations and scarring.^{5,60,61} Those containing ethyl chloride are flammable, so care must be taken around lasers or sources of heat.^{5,6,61} Other cooling devices that

have been used in dermatology include sapphire cooling laser tips and the Zimmer™ machine.^{5,6} The benefits of these technologies are twofold; they provide anesthesia for the patient and protect against laser-induced thermal injury and blistering. A thorough list of cooling applications is found in Table 12-5.

Table 12-5. Cooling Applications Used in Dermatologic Surgery

Ice/cool packs
Liquid nitrogen
Zimmer™ cooling device (Zimmer Medizin Systems, Irvine, CA) (forced air cooling)
Frigiderm™ (Delasco, Council Bluffs, IA) (100% dichlorotetrafluoroethane)
Ethyl Chloride™ (Gebauer Company, Cleveland OH) (50% dichlorodifluoromethane, 50% trichloromonofluoromethane)
Instant Cold Spray™ (HL Moore, New Britain, CT) (10% isopentane, 90% butane)

Data from Plotkin S: Clinical comparison of preinjection anesthetics, *J Am Podiatr Med Assoc.* 1998 Feb;88(2):73–79.

Cryoanesthesia can also be performed effectively using liquid nitrogen; for needle-phobic patients, shave biopsies may be anesthetized using a brief liquid nitrogen spray, though the dermatopathologist should be informed as theoretically freeze artifact could occur.

Iontophoresis

Iontophoresis utilizes electric current to deliver anesthetic solution into the skin without the pain of a needle.⁵ Anesthetic delivery works well, with some studies showing a 20- to 60-fold increase in lidocaine penetration.⁶² Although there is a learning curve and expense for the machinery, iontophoresis is a very effective approach to enhance numbing efficacy, especially in the pediatric population.⁶³

ANESTHETIC ADMINISTRATION

Local infiltration

Local anesthesia can be administered either intradermally or subcutaneously. Intradermal injections are superficially placed, create more tissue distortion, have a faster onset of action, and are slightly more painful.^{5,6,14} Deeply placed subcutaneous injections are less painful and create less tissue distortion than intradermal injections, but have a slower onset of action and shorter duration of action.^{5,6,14}

It is important to learn proper injection technique to make the experience most comfortable for the patient. Methods to achieve a more painless and comfortable injection experience include those listed in [Table 12-6](#).

Although studies have been conducted to evaluate pain level with different types of local anesthetics, only a few have had a sufficiently large sample size. One study found that bupivacaine with epinephrine elicited the most discomfort, and lidocaine with epinephrine the least.⁶⁴ Another prospective, randomized, double-blind study found that 3% mepivacaine and 2% lidocaine with epinephrine induced a similar amount of pain on injection, with the lidocaine group demonstrating a slightly less, though not clinically significant, amount of moderate pain reported.⁶⁵ Further studies would be helpful to explain these differences and standardize recommendations for local anesthetic use.

Table 12-6. Methods Used to Achieve a More Painless and Comfortable Injection

■ Supporting the head of the patient while numbing ■ Talking to and encouraging the patient during local administration ■ Hiding the needle from the patient's direct view ■ Playing relaxing music ■ Having the patient recline comfortably ■ Using cool compresses, ice or cryorefrigerants prior to injection ■ Applying topical anesthetics prior to injection ■ Using a smaller diameter needle, e.g., 30- or 31-gauge needle ■ Warming the solution prior to injection ■ Injecting perpendicular to the skin	■ Injecting slowly ■ Neutralizing the pH of acidic lidocaine and epinephrine by mixing (10:1) with 8.4% sodium bicarbonate ■ Employing distraction techniques such as tapping other areas of the skin while actively numbing ■ Having the patient use a squeeze toy ■ Holding the patient's hand while the injection is being performed ■ Stretching the skin taught with the nondominant hand while injecting ■ In cases where multiple punctures are required, performing needle reentry in areas previously anesthetized ■ Employing conscious sedation for small children ■ Utilization of nerve blocks or tumescent anesthesia when large areas of anesthesia are needed
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Field (ring blocks)

Field (ring) blocks use local anesthesia that is injected circumferentially around the operative site.⁶ Multiple injections are required with each being placed in an area that was previously anesthetized. Ring blocks are useful in those instances where direct infiltration into the surgical site should be avoided, where nerve blocks are not an option, and for larger surgical areas. In dermatologic surgery, this approach is ideal for the excision of cysts,^{5,6} skin cancers,¹⁴ and when performing hair transplant procedures.¹⁴ It is important to inject the local anesthetic in both deep and superficial planes to optimize the numbing effect.⁵ Ring blocks conserve the total amount of anesthetic that needs to be injected. It is important to wait 5 to 10 minutes after the completion of this block to allow for adequate anesthesia and optimal hemostasis. To maximize hemostasis, the central area may be painlessly infused after completing the ring block.

Ophthalmic uses

A thorough understanding of ophthalmic anesthesia is important for the dermatologist. From laser resurfacing to lower lid blepharoplasty to ocular Mohs surgery procedures, the knowledge of how and when to use these agents is essential. The most commonly used ophthalmic anesthetics are tetracaine, proparacaine, benoxinate,^{6,66} cocaine, and lidocaine.⁶⁶ With these preparations, the anesthesia is limited to conjunctiva, cornea, and anterior sclera.⁶⁷

Tetracaine ophthalmic preparations come in concentrations ranging from 0.5% to 2%. It is administered onto the cornea and conjunctiva directly using one to two drops. The onset of anesthesia with tetracaine occurs within 30 seconds,⁴¹ and the duration of action varies from 10 to 25 minutes. It is important to let patients know that they might initially experience a slight burning sensation in their eyes, which lasts for a few seconds after the application to the globe.⁶ Tetracaine can cause keratopathy in concentrations as low as 0.5%.⁶⁸

Proparacaine is commercially available as a 0.5% solution. It is mixed with 0.2% chlorobutanol and 1:10,000 benzalkonium chloride, which are added as preservatives. Proparacaine induces less stinging than tetracaine, and has been shown to last longer (10.7 vs. 9.4 minutes).⁶⁹

EMLA cream can be used on periocular skin; however, care must be taken to avoid direct contact with the globe. There have been reports of corneal injuries after using EMLA for laser resurfacing procedures.⁵⁴ Application of EMLA has been shown to provide effective eyelid skin anesthesia prior to performing cosmetic and traditional surgery procedures.^{70,71}

Allergies to topical ophthalmic anesthetics are uncommon, and cross sensitivities are rare. Reactions usually occur after repeated administration and usually with the ester agents.⁷² These can manifest as conjunctival hyperemia, chemosis, swelling of the eyelids, lacrimation, and itching.^{68,72}

Ocular infiltrative techniques

For lower eyelid procedures involving the tarsal plate or blepharoplasty techniques, a 30-gauge 1-in needle is used. After instilling numbing drops, direct local infiltration is accomplished using buffered 1% lidocaine with 1:100,000 epinephrine.⁷³ The needle is inserted 3 to 5 mm below the tarsal plate in the middle of the palpebral conjunctival vessel arcade. The barrel of the syringe is withdrawn prior to injection to ensure that no blood vessel has been inadvertently entered, as evidenced by the absence of a blood flash in the syringe. The lower lid is stretched downward and 2 to 3 cc of anesthesia slowly injected. The infraorbital skin is gently massaged and a cool compress applied to enhance the vasoconstrictive effects of local anesthesia. After initial numbing with buffered lidocaine, 1 cc of bupivacaine 0.5% with 1:10,000 epinephrine can be added to increase local anesthesia duration.⁷⁴ This is most helpful when surgery time is expected to run 2 to 4 hours⁷⁴ as can sometimes be seen with ocular Mohs surgery or longer blepharoplasty procedures.

For upper eyelid procedures, a 30-gauge 1-in needle is also utilized. First, cool compresses are applied to the lateral orbit. Subsequently, a 2- to 3-cc buffered lidocaine bolus is administered near the lateral canthus with the needle oriented tangentially to the orbital septum. Though corneal shields are often recommended prior to numbing, they are usually not necessary for the experienced injector. The needle is advanced to a position halfway over the eyelid, and a fluid bolus is slowly injected retrograde. The newly created anesthetic bleb is then massaged medially with a cotton-tipped applicator, which expands the anesthetic over the entire length of the upper eyelid. As

with lower eyelid anesthesia, bupivacaine can be added to increase the anesthetic duration.⁷⁴

Tumescent anesthesia

Tumescent anesthesia was first described in the 1970s.⁷⁵ This important development was a major one in medicine because it allowed surgeons to deliver large volumes of local anesthesia in a safe fashion.⁷⁶ As opposed to concentrated lidocaine solutions, the tumescent anesthesia technique allows the surgeon to safely use up to 55 mg/kg lidocaine in one operative session.^{6,28,77} corresponding to injection volumes ranging from 50 to 4000 mL. The main constituents of tumescent anesthesia are normal saline, lidocaine, sodium bicarbonate, and epinephrine.^{6,78} Dilution recipes vary from 0.25% to 0.3% concentrations and are adjusted based on the type of procedure being performed (Table 12-7).

Table 12-7. Tumescent Anesthesia Recipes for Various Skin Procedures

Area	Indications	Formula
Face, neck	Thermi RF™, lipo, lifts, laser resurfacing	Xylocaine 1% plain—75 mL, 8.4% NaHCO ₃ —2.5 cc, epinephrine 1:1000—1 cc, volume 250 cc
Scalp	Flaps, hair transplants	Xylocaine 1% plain—75 mL, 8.4% NaHCO ₃ —2.5 cc, epinephrine 1:1000—1 cc, volume 250 cc
Abdomen	Liposuction, flaps, Thermi RF™ tightening	Xylocaine 1% plain—150 mL, 8.4% NaHCO ₃ —10 cc, epinephrine 1:1000—1 cc, volume 1000 cc
Back	Flaps, lipoma removal	Xylocaine 1% plain—75 mL, 8.4% NaHCO ₃ —2.5 cc, epinephrine 1:1000—1 cc, volume 250 cc
Hips, thighs, legs	Liposuction, RF, vein ablation	Xylocaine 1% plain—100 mL, 8.4% NaHCO ₃ —10 cc, epinephrine 1:1000—1 cc, volume 1000 cc
Arms	Liposuction, Thermi RF™ tightening	Xylocaine 1% plain—150 mL, 8.4% NaHCO ₃ —5.0 cc, epinephrine 1:1000—1 cc, volume 500 cc

Tumescent anesthesia has been widely used in dermatologic surgery for liposuction procedures, hair transplants, facelift procedures, scalp flaps, large tumor removals (e.g., lipomas, sarcomas), infiltrative RF procedures, and laser/RF varicose vein treatments.^{5,6,74} It is administered slowly using a pumping device or large syringe. Large multiport cannulas or 18- to 20-gauge blunt-tipped spinal needles are often used to deliver the anesthesia.

For a more comfortable injection, ice packs and blebs (0.5 to 1 cc) of 1% buffered lidocaine are used in the specific area(s) to be anesthetized. The surgeon infiltrates into these blebs slowly at first, and subsequently increases the speed of infiltration as patient comfort allows. Warming the tumescent

mixture to 104°F or 40°C has also been shown to reduce the patient discomfort.^{6,79}

The value of tumescent anesthesia in dermatologic surgery patient is that (1) it is a safe and effective way to provide local anesthesia, (2) it serves to minimize bleeding,⁷⁷ and (3) it eliminates the need for general anesthesia.⁷⁶ There is also an added benefit of a prolonged anesthesia effect^{80,81} that occurs when the tumescent mixture is slowly released into the bloodstream from deeper subcutaneous tissues.

Neck tumescent anesthesia is useful for liposuction,⁸² laser lipolysis,⁸³ RF tightening, skin resurfacing, and large flap procedures.^{6,84} To properly tumesce the neck, the patient is first thoroughly prepped with Betadine™ or Chlorhexidine™, and sterile drapes are placed. The patient's neck is slightly extended for proper visualization, and three blebs of 1 cc of buffered lidocaine are placed in the right infra-auricular crease, submental crease, and left infra-auricular crease. A small 2-mm punch or stab incision is placed in these same areas. A 20-gauge spinal needle or infiltrating cannula delivers the anesthesia. Slow and deliberate infusion is performed, with care taken to inject superficial to the platysma muscle. The neck is divided into the right, central, and left submentum (Fig. 12-4). To ensure complete numbing, the targeted area of tumescence should reach 1 cm beyond the planned treatment area. Usually, 150 to 500 cc of tumescent solution is required for complete anesthesia.^{82,85} After 20 to 30 minutes,⁷⁷ the patient should be ready for surgery with the anesthetized area appearing blanched and feeling soft and smooth.



Figure 12-4. The neck is divided into the right (*blue*), central (*green*), and left (*red*) submentum.

NERVE BLOCKS

Nerve blocks are extremely useful in dermatologic surgery. They help to optimize patient comfort,¹⁴ minimize tissue distortion,⁶ and enhance patient safety.⁶ Nerve blocks require an in-depth understanding of human anatomy and can be difficult to learn for the novice. Patience and persistence are necessary for the surgeon trying to master the art of nerve blocks. They are

especially useful for skin procedures of the head and neck, digits, foot, genitals, hand, and lateral thigh regions.^{5,6}

Nerve blocks require fewer needlesticks to achieve anesthesia.⁶ Selectively using combinations of lidocaine and bupivacaine allows for enhanced anesthetic duration and safety. Sometimes, additional epinephrine or a tourniquet is necessary to enhance hemostasis.⁶ Some authors have historically suggested that the use of epinephrine in the digital region poses a risk and should be avoided,⁵ though the consensus now is that epinephrine is safe for properly performed digital blocks.^{86,87} The risks associated with nerve blocks are rare, but can include direct nerve injury, pain, dysesthesia, neurapraxia, infection, and vessel trauma,^{6,88} which can cause unwanted bruising and/or hematoma formation.^{74,89}

To perform a nerve block, a 30-gauge ½- or 1-in needle is used. It is important to slowly advance the needle and to aspirate before injecting to avoid direct injection into a blood vessel.⁶ The use of topical anesthetics, cryorefrigerants, or distractive vibratory⁹⁰ tapping at sites distant to the nerve block area can help with patient comfort. Once the needle is placed in the correct location, small amounts of anesthetic are injected and allowed to diffuse strategically. Nerve size and type tend to correlate with the time to numb.⁹¹ Once a nerve block has been administered, it is important to wait for at least 5 to 10 minutes before proceeding with surgery.^{5,6} Repeat injections are sometimes required to complete the block. Patients should be made aware of this before starting their procedure.

HEAD AND NECK NERVE BLOCKS

The head and neck areas of the body have a vast array of nerve and blood vessel structures. The trigeminal nerve (cranial nerve V) and cervical plexus are responsible for the majority of sensory innervation for these areas (Fig. 12-4).^{5,92} The trigeminal nerve can be divided into three main components. These include the ophthalmic branch (V1), maxillary branch (V2), and mandibular branch (V3).^{5,6,92} They are responsible for sensation to the forehead, cheeks, conjunctiva, teeth, lips, nose, and chin. There are specific facial landmarks, which serve to identify where to inject anesthetic to numb

certain regions of the face (Fig. 12-5).⁹² The cervical plexus¹⁰⁹ supplies sensory innervation to the ear, neck, jaw, and posterior scalp.^{5,92} This plexus emanates from the anterior rami of four superior cervical nerves.⁵ Knowledge of their emergence points is helpful to correctly anesthetize the posterior auricle and angle of the jaw.

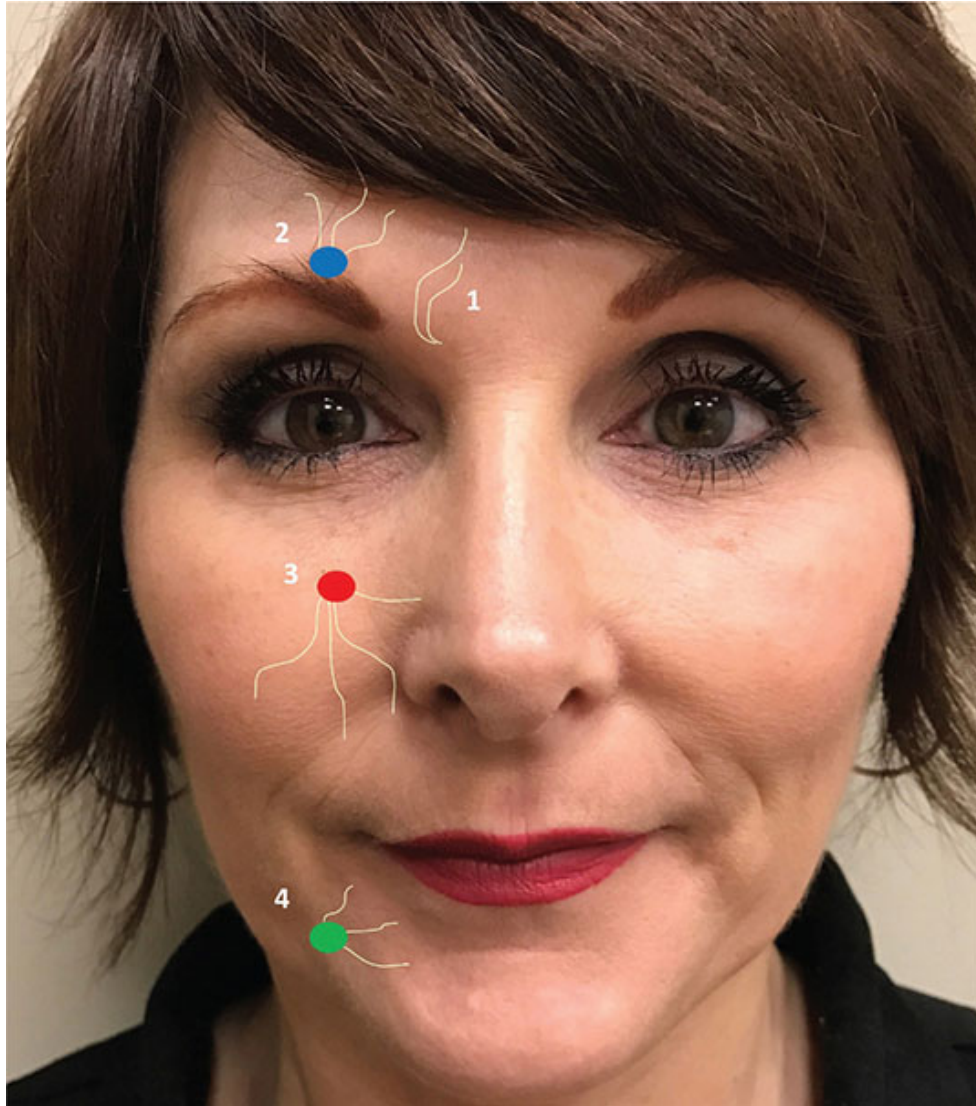


Figure 12-5. There are specific facial landmarks, which serve to identify where to inject anesthetic to numb certain regions of the face. The supratrochlear (1) and supraorbital (2) nerves, the latter of which emanates from the supraorbital foramen (*blue*) supplies sensation to much of the forehead. The infraorbital nerve (3) exits from the infraorbital foramen depicted in *red*. It is located 1 cm below the infraorbital rim and is responsible for innervation of the upper lip and medial cheek. Finally, the mental foramen, seen in *green*, is the exit portal for the mental nerve (4), which innervates the lower lip and chin.

Supraorbital and supratrochlear nerve blocks

The supraorbital and supratrochlear nerves provided sensation to the ipsilateral forehead and scalp (Fig. 12-6).⁵ They arise from the ophthalmic branch of V1.^{6,15,92} The supraorbital nerve emanates from the supraorbital notch, which is located on the superior orbital rim near the mid-pupillary line.⁵ The supratrochlear nerve is located about 1.2 to 1.7 cm medial to this notch.⁵ Both nerves can be blocked simultaneously by palpating the notch, gently pinching up on the skin, and injecting 1 to 2 cc of local anesthetic toward the midline.^{14,92–94} Care must be taken to aspirate before injecting to avoid inadvertent trauma to the supraorbital and supratrochlear arteries, which run medial to these nerves. The use of cool compresses before injection can also help to minimize this risk by inducing transient vasoconstriction.

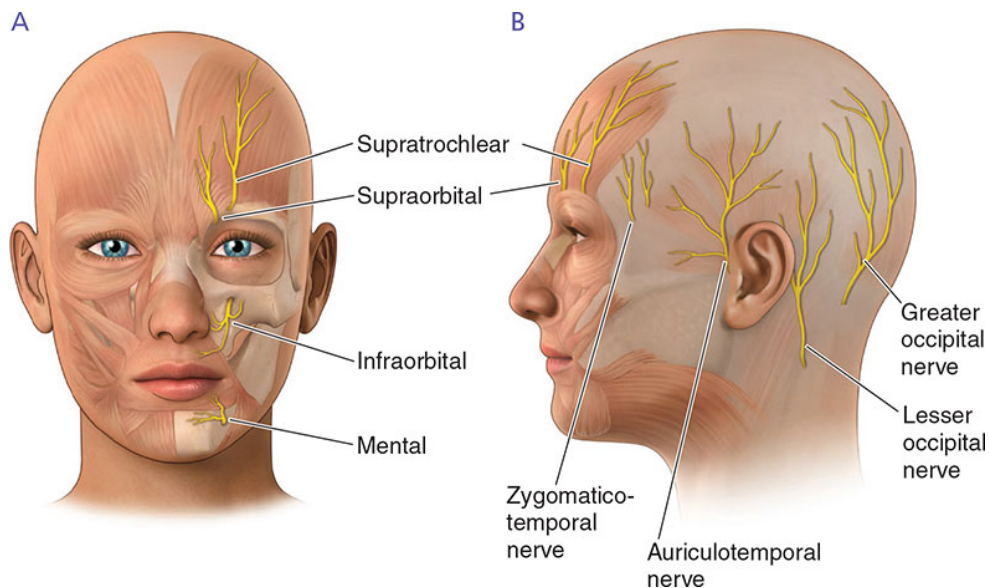


Figure 12-6 . The supraorbital and supratrochlear nerves provide sensation to the ipsilateral forehead and scalp.

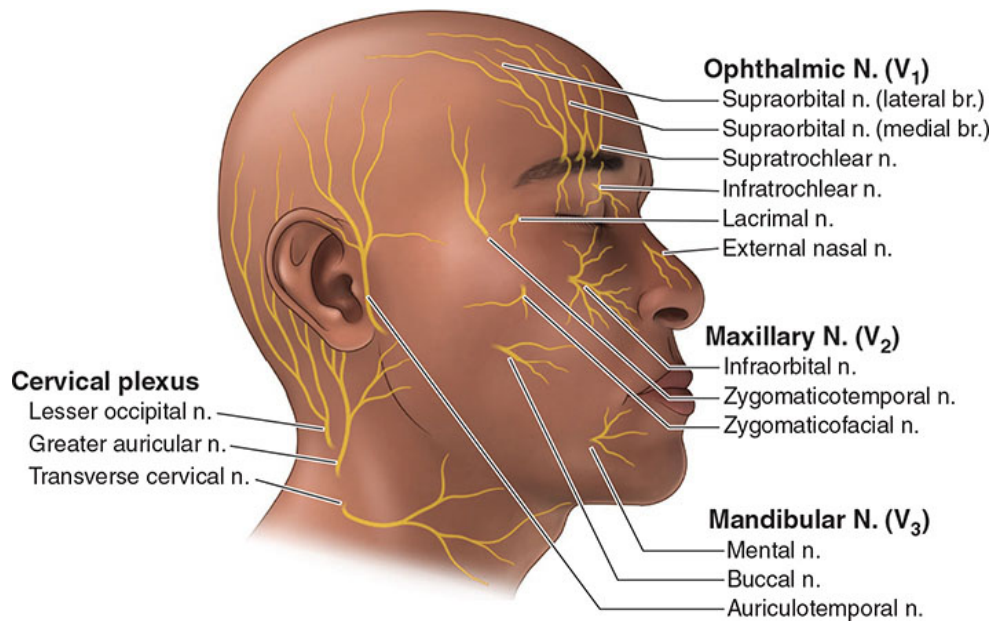


Figure 12-7. Auriculotemporal (AT) nerve block. The AT nerve provides sensory innervation to the ipsilateral anterior ear and temple, and is another branch of V3. It can be blocked, with mouth open, by palpating the TMJ and injecting just superior to the joint pivot point using 2 to 3 cc of anesthetic.

Infraorbital nerve block

The infraorbital nerve provides sensation to the ipsilateral lower eyelid, nasal sidewall, upper lip, and medial cheek (Fig. 12-6).^{5,6,14,92} It derives from the maxillary branch of V2 and is the largest branch of the maxillary nerve.⁶ Its exit onto the face occurs at the infraorbital foramen, which can be palpated as a notch just medial to the mid-pupillary line, approximately 1 cm below the infraorbital rim.^{6,14,92}

The infraorbital nerve can be anesthetized either percutaneously or intraorally.⁶ The intraoral approach is considered less painful.^{6,14} With this blocking technique, the maxillary gingival sulcus lateral to the canine may be topically numbed¹⁴ with 20% benzocaine left in place for 1 minute. A small bleb of buffered lidocaine is subsequently placed using a 30-gauge 1-in needle; given the minimal pain associated with this procedure, topical anesthesia is not required. After 10 to 15 seconds, the needle is advanced tangentially above the maxillary periosteum toward the notch. After negative aspiration, 1 to 3 cc of anesthetic is slowly injected. Gentle movement of the lateral upper lip with the nondominant hand can reduce discomfort as the

injection is administered. The percutaneous route, like the supraorbital block, is performed by palpating the notch of the foramen, gently pinching up on the skin, and slowly injecting a similar small amount of anesthetic solution. Topical numbing agents and/or cool compresses can be employed with the percutaneous approach to optimize patient comfort.

Anterior ethmoidal (external nasal) nerve block

The external nasal nerve is a branch of the anterior ethmoidal nerve and is located between the upper lateral nasal cartilage and lower border of the nasal bone.⁵ Anesthesia of the ipsilateral nasal tip, columella, and nasal dorsum⁵ is obtained by injecting 1 to 2 cc of anesthetic at a point between the mobile cartilage and fixed nasal bone periosteum.⁹² One way to make this block less painful, as is performed with full-face laser resurfacing cases, is to start with the supraorbital nerve block and gradually advance the anesthesia medially toward the nasal root and lateral mid-nasal sidewall. This may allow for a much better experience for the patient.

Mental nerve block

The mental nerve provides sensation to the ipsilateral chin and lower lip, including gingiva and mucosa.^{5,14} It is the terminal branch of the mandibular nerve (V3) and emerges from the mental foramen^{6,14} at a point 2.5 cm lateral to midline of the chin.^{5,6} With time, as the mandible recedes, the location of the foramen shifts to a point closer to the upper mandibular margin.^{5,92}

Like the infraorbital nerve block, the mental nerve block can be performed either intraorally or percutaneously.^{5,6} The intraoral approach is considered less painful and uses topical benzocaine gel applied to the gingival sulcus between the first and second premolars.⁵ After 60 seconds, a small bleb of buffered lidocaine is placed using a 30-gauge 1-in needle. To achieve an effective block, 1 to 3 cc of anesthetic is administered per side.

Auriculotemporal nerve block

The auriculotemporal (AT) nerve provides sensory innervation to the ipsilateral anterior ear and temple and is another branch of V3.⁶ Its course runs deeper and posterior to the temporomandibular joint (TMJ) before it exits superficially to join a course parallel with the superficial temporal artery.⁶ The AT nerve can be blocked with mouth open by palpating the TMJ and injecting just superior to the joint pivot point using 2 to 3 cc of anesthetic (Fig. 12-7).^{5,6,92}

Transverse cervical and greater auricular nerve blocks

The transverse cervical and greater auricular nerves provide sensation to the posterior auricle, angle of the mandible, and anterior neck.^{6,93} The greater auricular nerve follows the course of the external jugular vein and innervates the posterior auricular area and ipsilateral angle of the jaw.⁶ The transverse cervical nerve is located 1 cm inferior to the greater auricular nerve and migrates anteriorly, providing sensation to the ipsilateral central mandible and anterior neck.^{6,93} Both nerves derive from the cervical plexus and emerge at a well-recognized landmark known as Erb's point.^{5,6} To help accentuate accurate injection into this area, the head can be turned 45 degrees against resistance.^{5,6} Once Erb's point is identified, 2 to 3 cc of local anesthesia is injected.⁹² This will result in the numbing of both nerves and an effective field of anesthesia prior to surgery.

EXTREMITY NERVE BLOCKS

Nerve blocks for the extremities are also valuable to know and understand. They are quite effective for hand, foot, and digital numbing,^{5,6} and are excellent for nail avulsion, wart treatment, and bunion surgery. The following will review some of the common extremity nerve blocks that are used in dermatologic surgery.

Digital blocks

Digital blocks are effective for numbing the nails, toes, and fingers.^{5,6} The fingers are innervated by two ventral and two dorsal nerves¹⁴ that run lateral to the digit and usually follow the course of the palmar and dorsal digital arteries (Fig. 12-8).⁶ Proper technique allows the nails and fingers to be rapidly anesthetized. As previously mentioned, the use of epinephrine for digital blocks is no longer controversial as several studies have shown it to be safe.^{86,87}

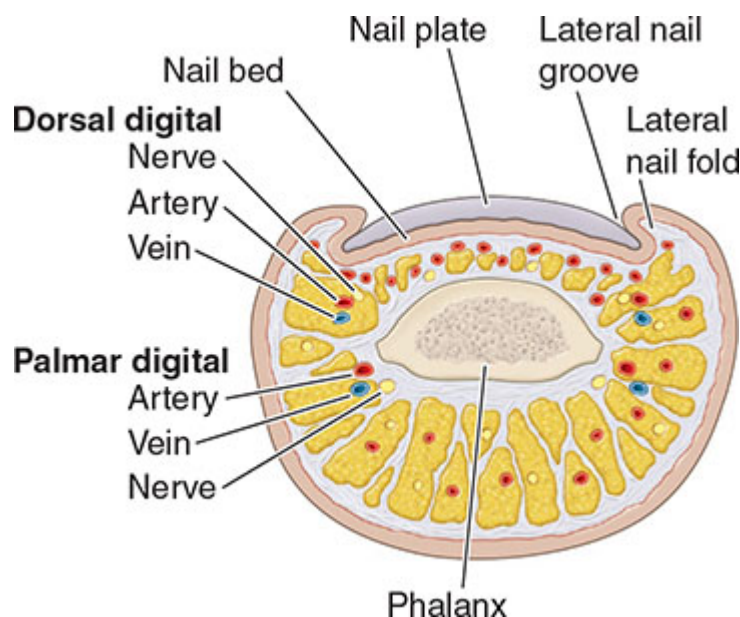


Figure 12-8. The fingers are innervated by two ventral and two dorsal nerves that run lateral to the digit and usually follow the course of the palmar and dorsal digital arteries.

Several digital blocks are available. The most commonly used approach for nail surgery is the distal digital (“wing”) block. Its advantages are a quick onset of anesthesia, the use of smaller volumes of anesthetic, and a tumescent effect providing hemostasis. A dorsal approach to finger anesthesia is considered less painful.^{5,38} Lidocaine 1% to 2%, buffered, or ropivacaine 0.25% are appropriate choices for this indication. 0.5 mL of anesthetic is injected into a point 5 mm proximal and lateral to the junction of the proximal and lateral nail folds on each side of the digit. If a surgeon chooses to use epinephrine in their anesthetic, there should be minimal risk of intra-arterial injection due to the small caliber of arterioles in this anatomic location. If using lidocaine, then the addition of bupivacaine 0.25% to 0.5% will prolong anesthesia for up to 8 to 12 hours.

The proximal digital block is of slower onset, and up to 20 minutes may be needed before the complete numbing of the distal tip of the digit takes place. Unlike the distal digital block, it carries a potential risk for damage to the neurovascular bundles. A cryorefrigerant, cold air,⁹⁵ or topical anesthetic cream is first applied over the proximal MCP joint at two points lateral to the digit. Approximately 1 mL of anesthetic is injected laterally at the level of the metacarpophalangeal or metatarsophalangeal joints into each side of the digit. Care should be taken to draw back on the syringe before injection to avoid injecting into an arteriole of the common digital artery.

The transthecal block is a useful approach for surgery of fingers two, three, and four. Due to anatomic variation, this approach is not advised for surgery on any other digit. Its advantages are rapid onset (2 to 5 minutes) and the absence of risk to neurovascular bundles, as the needle is inserted on the palmar aspect of the digit. A rare complication is injury to the flexor tendon that can result in scar or trigger finger.

A digital tourniquet is often employed for additional vasoconstrictive effects. Tourniquet time should be limited to 15 minutes⁵ with no more than 8 cc of anesthesia administered per digit in one setting.^{5,14}

Hand and wrist blocks

Nerve blocks of the hand and wrist are useful, especially given that multiple injections are required in this sensitive area,⁵ and topical anesthetics do not work well.⁶ The median, ulnar, and superficial radial nerves provide sensory innervation to hand and wrist.⁵

The median nerve provides sensation to the first three-and-a-half fingers on the palmar side, and dorsal second, third, and medial fourth digits (Fig. 12-9).⁵ It is located between the palmaris longus and flexor carpi radialis tendons.⁹⁶ The injection site for the median nerve is located just below the proximal wrist.^{6,96,97} A needle is advanced just medial to the palmaris longus tendon under the flexor retinaculum, and 3 to 5 cc of local anesthetic is used to numb the radial side of the palm.^{6,96} As always, it is important to avoid intra-arterial injection when administering anesthesia.⁹⁷

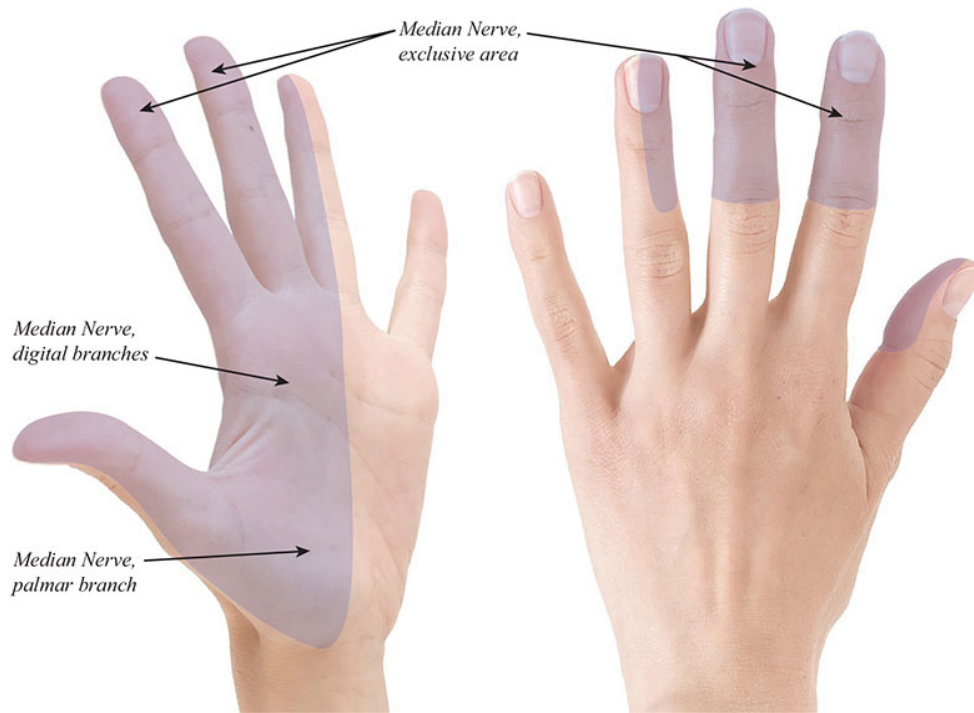


Figure 12-9. The median nerve provides sensation to the first three-and-a half finger on the palmar side, and dorsal second, third, and medial fourth digit.

The ulnar nerve provides sensory input to both the palmar and dorsal sides of the fifth, and lateral half of the fourth digit (Fig. 12-10).⁵ The nerve runs deep to the flexor carpi ulnaris tendon and inserts into the pisiform bone.^{96,97} The ulnar block is placed lateral to the flexor carpi ulnaris tendon on the proximal wrist crease.⁵ Again, careful injection technique is important because the nerve runs just medial to the ulnar artery.⁹⁷ The second approach is to administer the block proximally at the elbow (Fig. 12-13) between the epicondyle of the humerus and the olecranon process.^{96,97}

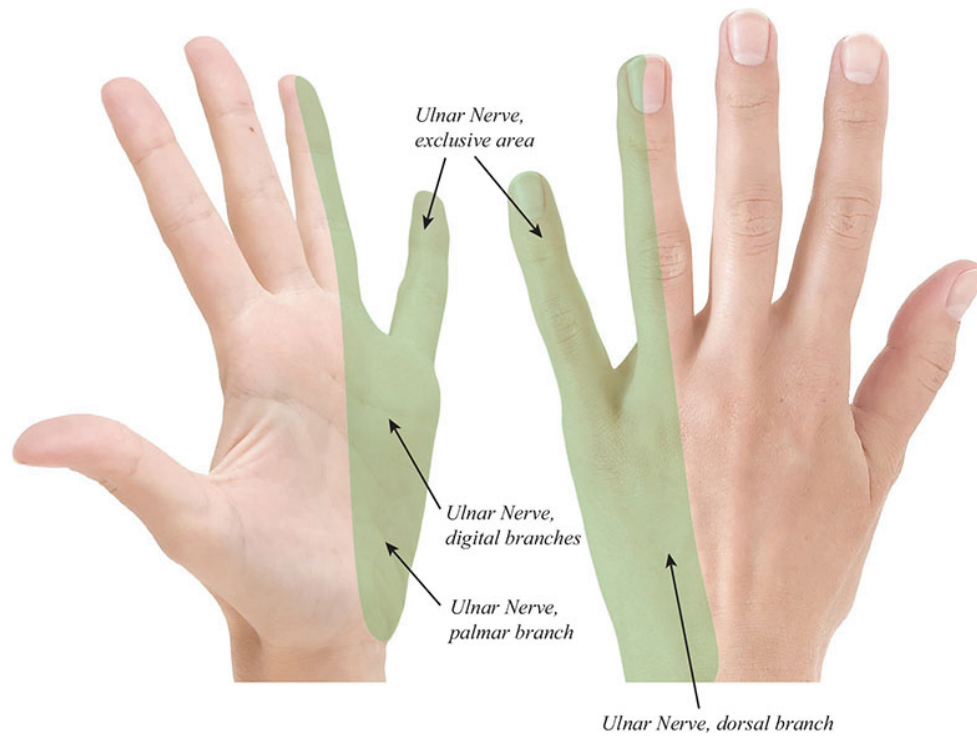


Figure 12-10. The ulnar nerve provides sensory input to both the palmar and dorsal sides of the fifth, and lateral half of the fourth digit.

The radial nerve provides sensory input to two-thirds of the dorsal hand (Fig. 12-11).⁵ It runs just lateral to the radius and follows a course extending from the wrist to the PIP joint of the second, third, and fourth, and dorsal side of the first digit.⁵ The radial block is performed by injecting lateral to the radial artery and deep to the flexor carpi radialis tendon.⁹⁶ It is an effective way to provide anesthesia to the palmar surface of the thumb.⁶



Figure 12-11. The radial nerve provides sensory input to two-thirds of the dorsal hand.

Foot and ankle blocks

The posterior tibial, saphenous, sural, and superficial and deep peroneal nerves mediate sensory innervation to the foot and part of the ankle.⁵ A thorough understanding of their anatomic routes is important.

The posterior tibial nerve innervates the majority of the plantar surface of the foot, except for its medial aspect.⁶ It is anesthetized at the medial malleolus,⁵ where the nerve runs posterior to the posterior tibial artery (Fig. 12-12). The injection is performed with the patient resting supine and the foot externally rotated.^{98,99} 3 to 5 cc of local anesthetic is injected at the upper portion of the medial malleolus and anterior calcaneal tendon.^{5,99}

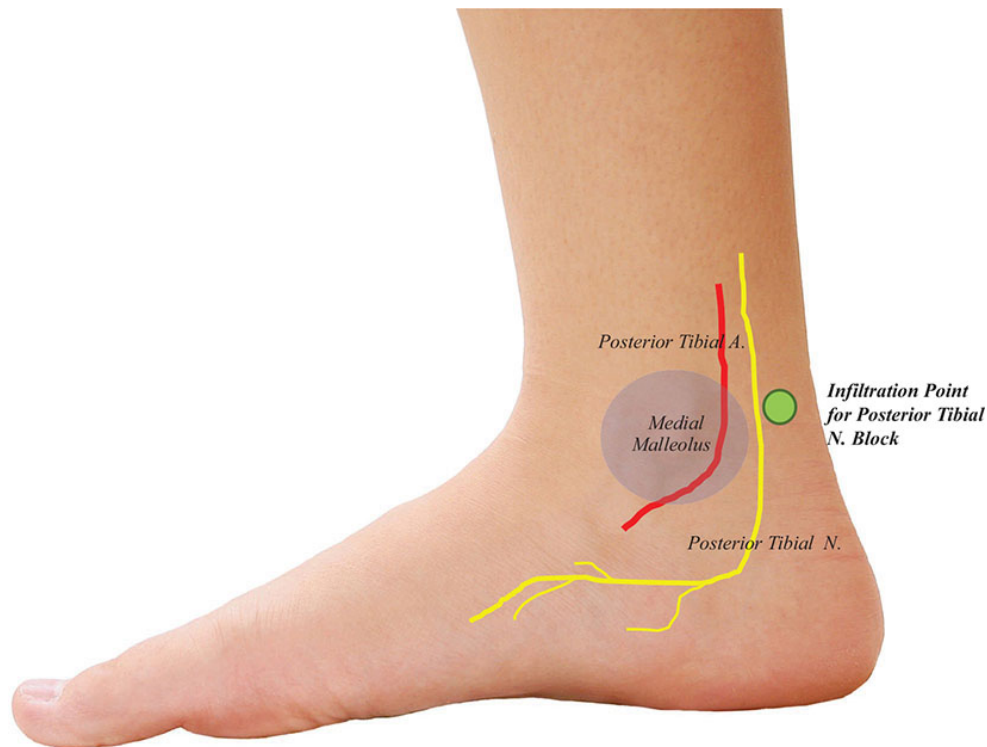


Figure 12-12. The posterior tibial nerve innervates the majority of the plantar surface of the foot, except for its medial aspect and is anesthetized at the medial malleolus, where the nerve runs posterior to the posterior tibial artery.

The saphenous nerve innervates the medial aspect of the plantar foot (Fig. 12-13). It travels along the medial calf, anterior to the medial malleolus and medial to the saphenous vein.⁵ The block is performed by injecting 3 to 5 cc of anesthetic anterior to the medial malleolus and medial to the saphenous vein.^{6,98}

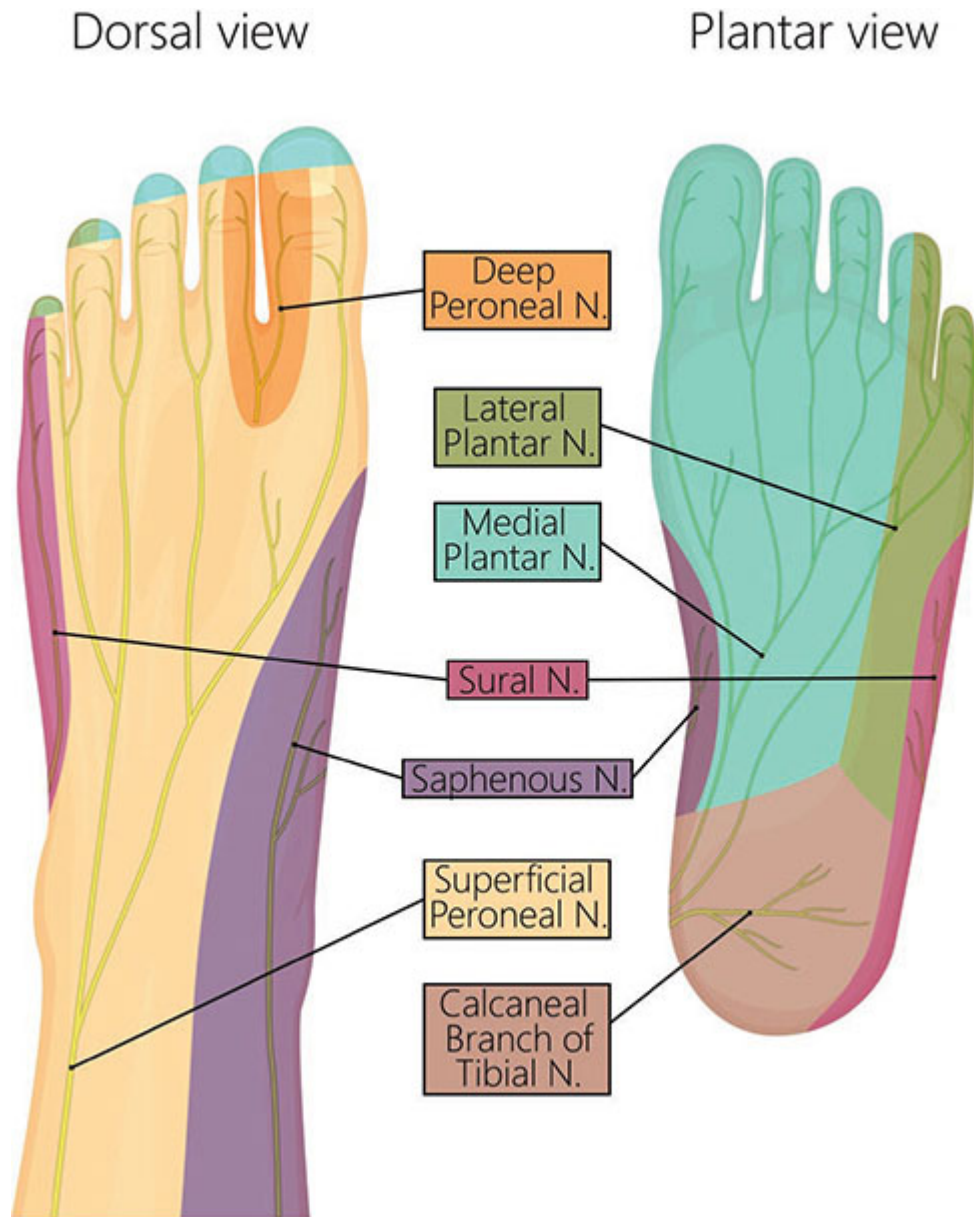


Figure 12-13. The saphenous nerve innervates the medial aspect of the plantar foot.

The sural nerve is responsible for innervating the lateral aspect of the distal ankle and plantar foot (Fig. 12-13). It traverses laterally and more superficial than the posterior tibial artery, passing between the Achilles tendon and lateral malleolus on its way to the foot.⁵ To block the sural nerve, 3 to 5 cc of local anesthetic is injected between the posterior distal tip of the lateral malleolus and Achilles tendon (Fig. 12-14).^{99,100}

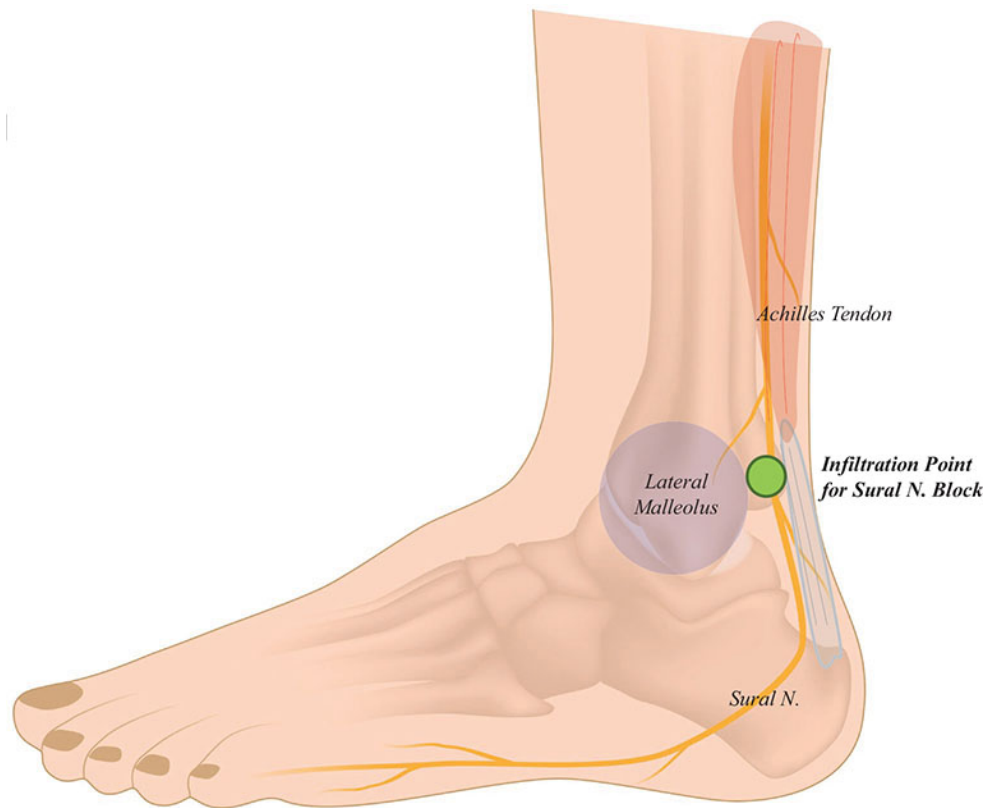


Figure 12-14. To block the sural nerve, 3 to 5 cc of local anesthetic is injected between the posterior distal tip of the lateral malleolus and Achilles tendon.

The superficial and deep peroneal nerves arise from the common peroneal nerve (Fig. 12-15).⁵ The superficial peroneal nerve runs initially deep along the anterolateral ankle and then splits superficially into dorsal digital nerves of all but the first web space of the foot.^{5,6} It is blocked by injecting 3 to 5 cc of local anesthetic between the anterior tibial surface and lateral malleolus (Fig. 12-14), providing anesthesia to the majority of the dorsal foot.^{6,98} The deep peroneal nerve innervates the first web space of the foot,^{5,6,101} and is located lateral to the extensor hallucis longus tendon and dorsalis pedis artery.⁶ It is a rarely blocked nerve because anesthesia to this area can be achieved by local infiltration.^{5,6} If a deep peroneal nerve block is required, then 3 cc of anesthetic is injected medial to the dorsalis pedis artery and lateral to the extensor hallucis longus tendon (Fig. 12-14).^{6,99}



Figure 12-15. The superficial and deep peroneal nerves arise from the common peroneal nerve.

ADVERSE REACTIONS

Local adverse reactions

Adverse reactions to local anesthesia vary in presentation; many reactions are due to improper technique¹⁴ or to added epinephrine,⁵ rather than to the anesthetic itself. Swelling, bruising, pain, and temporary disfigurement are some of the most frequently seen adverse reactions.^{5,14} Most resolve spontaneously without serious repercussions for the patient.

The use of epinephrine in local anesthetics has been reported to be associated with ischemia in digital areas.^{6,87} Those who suffer from collagen vascular disorders, vasospastic diseases, peripheral vascular disease, or uncontrolled hypertension are at somewhat higher risk.^{87,102} Digital ischemia

has been reported to occur when larger volumes of anesthesia are used even without the addition of epinephrine.¹⁰² Reversal can be achieved with topical nitroglycerin and/or injectable phentolamine 0.5 mg/mL.^{6,87} The latter is an alpha-adrenergic blocker that induces vasodilation.⁶

Vascular compromise has also been reported after using cosmetic filler agents containing local anesthetics.¹⁰³ Skin necrosis can occur with cosmetic injectables administered in the vascular areas of the glabella, nasal ala, and periocular areas, and it is important to be careful when injecting into these delicate areas.^{103,104} The use of cannulas and a retrograde injection technique can minimize the risk of vascular compromise. If ischemia occurs, pain or blanching of the skin is immediately noted. If not quickly treated, pain, cutaneous ulceration, and mottling of the skin can ensue.¹⁰³ A postcosmetic filler injectable kit (Fig. 12-16) containing hyaluronidase, topical nitroglycerin, thermal warm pack, aspirin, and 27-gauge needle with attached syringe can be helpful to treat such complications,^{103,104} and should be readily available for dermatologists who perform cosmetic injectable procedures. Importantly, these reactions are generally to the filler material rather than its associated anesthetic.

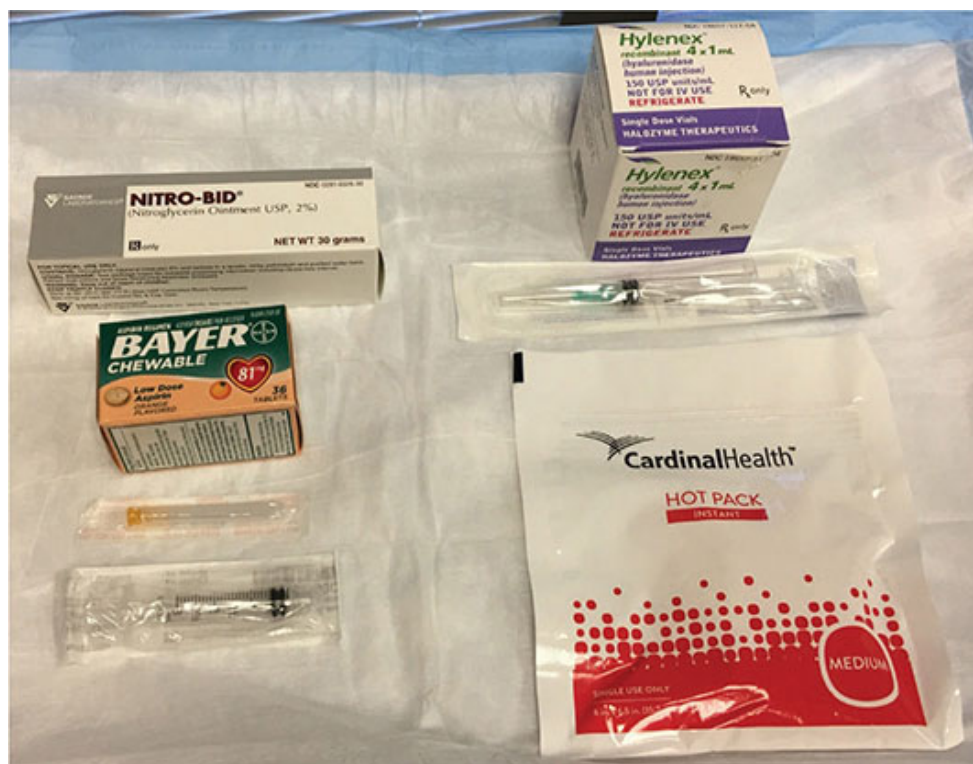


Figure 12-16. Filler complication kit.

Another rare complication is nerve damage.^{5,6,105} This reaction often results from block procedures where the nerve is injured from transection of the sheath, pressure from large volume of anesthesia, direct injection of anesthetic into the nerve, toxicity of the anesthetic agent, or vascular compromise to the nerve structure itself. Pain or paresthesia directly around or distal to the injection site is an early sign that a nerve injury may be occurring.⁶ If a patient complains of similar symptoms, then the procedure should be immediately stopped⁵ and patient promptly evaluated.

Chemical burns may be seen with the use of topical anesthetics, especially around the eyes.⁶ Many topical anesthetics such as EMLA have an alkaline pH.⁶ This allows for easier penetration into the skin. Ocular injuries such as corneal abrasions, ulcerations, erythema, and infections have been reported with the use of these agents.^{6,54} It is important to have an eyewash station immediately accessible in case a patient complains of eye burning or tearing from topical anesthetics. An immediate ophthalmologic assessment is important⁶ in order to minimize both ocular pain and the risk of permanent blindness.

Finally, thermal injuries can be seen after procedures that utilize tumescent anesthesia and/or nerve blocks.⁶ Burns from cigarettes and other sources of heat have been reported in patients postoperatively who do not realize that they are still numb.^{6,106,107} It is important to educate patients about the duration of their anesthesia prior to discharge from the office in order to minimize the likelihood of this adverse reaction.

Systemic reactions

Systemic reactions can also occur with topical and local anesthesia. Life-threatening adverse reactions are thankfully rare.^{5,6,108} The most common reactions usually involve the central nervous and cardiac systems. One of the most common reactions to local anesthetics is a vasovagal response.^{5,7} This is a psychogenic reaction that occurs in response to a patient's general anxiety, fear of needles, pain, or blood. Increased parasympathetic output leads to vagal-induced bradycardia, nausea, diaphoresis, lightheadedness,

and hypotension.^{5,6} Reversal is accomplished with Trendelenburg positioning,^{6,109} cool compresses, fluid intake, hand grip and leg crossing, smelling salts, and rarely midodrine or beta-blockers (Table 12-8).¹⁰⁹

Table 12-8. Treatment of Vasovagal Reaction

■ Place in Trendelenburg position ■ Smelling salts ■ Cool compresses on neck and face ■ IV hydration ■ Consider beta-blockers, midodrine ■ Leg compression ■ Patient education on how to respond to these reactions, especially if they experience “prodromal” symptoms ■ Training exercises “Applied Tension”—tensing muscles in arms, legs, and torso	■ Increase salt and fluid Intake to increase blood volume (e.g., sports drinks) prior to procedure ■ Moving/crossing legs and tightening muscles to keep BP from dropping prior to performing procedure ■ If a cardiac arrhythmia is found, implantation of a pacemaker may be needed
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Table 12-9. Recommended Doses of Lidocaine

Patient Category	Maximum Dose (mg/kg)
Children	
Lidocaine with epinephrine	3.0–4.5
Lidocaine without epinephrine	1.5–2.0
Adults	
Lidocaine with epinephrine	7.0
Lidocaine without epinephrine	4.5
Tumescent anesthesia	55

Data from Avram MR, Avram MM, Ratner D: *Procedural Dermatology*. China: McGraw-Hill Education; 2015.

Lidocaine toxicity

The recommended maximum doses of lidocaine without epinephrine is 4.5 mg/kg; with epinephrine 7.0 mg/kg; and 55 mg/kg with tumescent lidocaine solutions (Table 12-9).^{6,28,77} It is essential that the dermatologic surgeon recognizes that higher blood levels of lidocaine can be attained from inadvertent vascular injection or rapid drug absorption, for example, in mucous membrane areas.⁵ Similarly, one also must be aware that local anesthetic effects in fair individuals with red hair are difficult to establish.

Some authors postulate that this may be due to a mutation in the melanocortin-1 receptor which may affect neuromodulatory regulation within the central nervous system.¹¹⁰

Lidocaine metabolism can also be affected by pseudocholinesterase deficiency, liver disease, and interactions with certain medications.^{5,6,14} Lidocaine is an amide anesthetic and is metabolized by the hepatic cytochrome CYP3A4 and CYP1A2 enzymes.^{5,6} The use of large lidocaine doses in patients taking medications that inhibit these enzyme systems can lead to an increased risk of toxicity. Common medications including tetracycline, cimetidine, SSRIs, and fluconazole inhibit CYP3A4, resulting in increased lidocaine levels (Table 12-10).⁶ Beta-blockers can increase lidocaine levels by reducing cardiac and hepatic blood flow.⁶ With respect to renal function, no special adjustments need to be undertaken when administering lidocaine.⁶

Table 12-10. Drugs Causing Elevated Lidocaine Levels (Cytochrome p450-3A4 Inhibitors)

■ Amiodarone	■ Methylprednisolone
■ Azoles (Fluconazole, Itraconazole)	■ Metronidazole
■ Carbamazepine	■ Nicardipine
■ Cimetidine	■ Nifedipine
■ Clarithromycin	■ Pentoxifylline
■ Chloramphenicol	■ Propofol
■ Cyclosporine	■ Propranolol
■ Danazol	■ Quinidine
■ Dexamethasone	■ SSRIs
■ Diltiazem	■ Tetracycline
■ Erythromycin	■ Terfenadine
■ Isoniazid	■ Thyroxine
■ Methadone	■ Valproic acid
	■ Verapamil

Reproduced with permission from Robinson J: *Surgery of the Skin: Procedural Dermatology*, 3rd ed. London: Elsevier Inc; 2015.

Signs of lidocaine toxicity

Lidocaine toxicity occurs in a concentration-dependent fashion (Table 12-11). At lower levels (3 to 6 µg/mL), toxicity may manifest as circumoral paresthesia, euphoria, anxiety, talkativeness, or blurred vision.⁶ As toxicity progresses (5 to 9 µg/mL), vomiting, tremors, and restlessness ensue.^{5,6,28,111} At higher levels of 10 to 26 µg/mL, seizures, cardiopulmonary depression, and cardiac arrest can ensue.^{6,108}

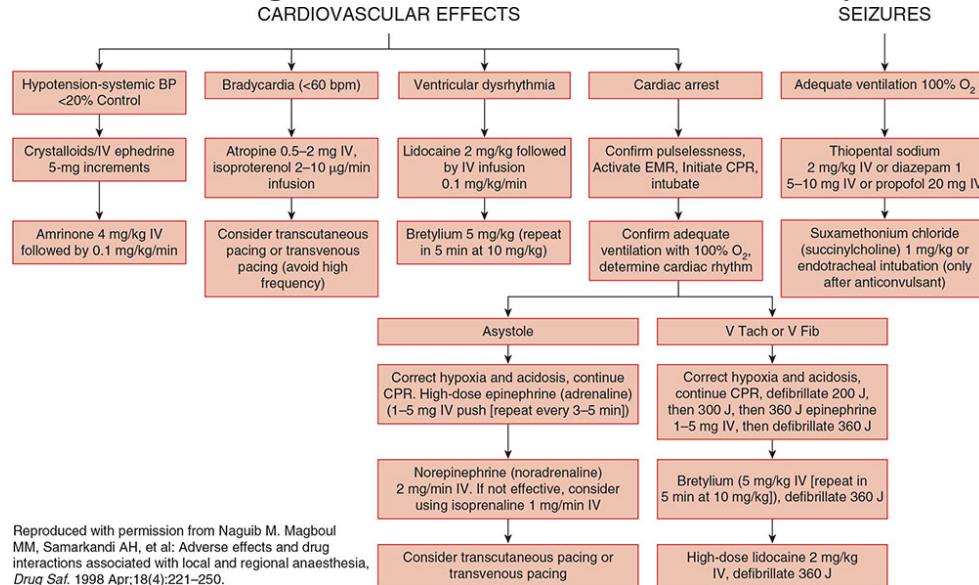
Table 12-11. Lidocaine Toxicity Based on Blood Serum Values

Stage	Serum Lidocaine Concentration (µg/mL)	Adverse Effects
I	1–6	Circumoral paresthesia, tinnitus, lightheadedness, agitation, talkative, drowsy, disoriented, metallic taste in mouth
II	6–12	Nausea, vomiting, muscle twitching, tremors, nystagmus, blurred vision, seizures
III	Greater than 12	Coma, respiratory arrest, dysrhythmia, cardiac arrest

When lidocaine toxicity begins to manifest, immediate cessation of drug delivery and basic steps to support the airway and circulation must be undertaken.^{5,6} After activating EMS and preparing for possible hospital transport, the initial management plan should be to stop anesthetic delivery, monitor vital signs, maintain ventilation, administer oxygen, and establish an IV line.⁶ Hypoxia and acidosis decrease the threshold for seizure induction and increase cardiotoxic effects.¹¹² Seizures are treated with diazepam, propofol, or thiopental sodium.¹¹² Hypotension is addressed by administering fluid boluses and sometimes adding vasopressors such as epinephrine or phenylephrine.¹¹² Bradycardia may require atropine or inotropic agents. When intubation is required, neuromuscular blockers such as succinylcholine

are often employed.¹¹² An algorithm reviewing the management of local anesthetic- induced systemic toxicity is outlined in Table 12-12.¹¹²

Table 12-12. Algorithm to Treat Lidocaine Toxicity



Bupivacaine toxicity

Bupivacaine is more cardiotoxic than other anesthetic agents and has a greater tendency to induce arrhythmias that are refractory to defibrillation.¹¹² This may be because it enters the sodium channel rapidly but leaves slowly.⁵ It also has the greatest propensity for inducing seizures.¹¹² In late trimester pregnancy, cardiotoxicity is more likely due to reduced venous return and increased progesterone levels.^{5,6,7}

Topical anesthetic systemic toxicity

There have been reported adverse effects and even fatalities with the use of topical anesthetics.^{28,113,114} Prolonged application with and without occlusion, use of inappropriately high concentrations, and application to large surface areas increase the risk of cardiotoxicity and central nervous system toxicity.¹¹³ Usually, the central nervous system is more readily affected by the pharmacological actions of local anesthesia than the

cardiovascular system.¹¹⁵ As with injected anesthetics, the initial symptoms of topical anesthetic toxicity include lightheadedness, circumoral numbness, diplopia, and tinnitus.¹¹³

With respect to reported fatalities from topical anesthetics, most reported subjects were young and received topical anesthesia prior to laser hair removal.^{6,116–118} Anesthetic application was performed under occlusion for an extended time. Two cases occurred after using compounded creams that were liberally applied to the legs^{6,116,117} for greater than 60 minutes under occlusion. Another case involved topical anesthetic application to the back.¹¹⁸ In some instances, no physician supervision was present, the patients applied the creams themselves, and no pre- and postoperative instructions were reviewed with the patient.

Rapid recognition of anesthetic toxicity is the most important step in managing an accidental overdose. If suspected, the anesthetic must be immediately washed off.¹¹³

Epinephrine toxicity

Concentrations of epinephrine greater than 1:100,000 have been reported to induce a higher rate of serious adverse events.^{5,8} The maximum dose of epinephrine that one can receive should not exceed 1 mg (1 mL of 1:1000 solution) over a 10-hour period.⁵ The dermatologist should be aware of any patient health risks, such as hyperthyroidism and cardiac disease, which can affect the metabolism and/or sensitivity to epinephrine.^{6,14} The most common side effect of epinephrine is transient tachycardia.^{14,119} This can progress, in rarer instances, to palpitations, sweating, tremors, pallor, and chest pain.^{14,120} Most of these adverse effects occur within 1 to 4 minutes after injection.^{14,119}

With respect to pregnancy, animal studies have shown that there is a reduction in uterine blood flow after epinephrine administration.^{5,121} Epinephrine is classified as a Category C drug.^{5,6,28,122} Pregnancy is considered a relative, though not absolute, contraindication to its use.⁵ Nonemergent usage should probably be delayed until after delivery.^{5,28,123} Absolute contraindications to epinephrine use include pheochromocytoma,

uncontrolled hyperthyroidism,⁵ and severe hypertension.⁶ A list of relative and absolute contraindications to epinephrine use can be found in Table 12-13.

Table 12-13. Absolute and Relative Contraindications to Epinephrine Use

Absolute Contraindications		Relative Contraindications	
Severe Hypertension		Beta-Blocker Administration	MAO Administration
Uncontrolled hyperthyroidism		Tricyclic antidepressant administration	Phenothiazine administration
Pheochromocytoma		Peripheral vascular disease	Unstable cardiac disease
Anxiety or psychiatric disorder			
Pregnancy (when large doses are required)			
Glaucoma			
Unstable diabetes mellitus			
Hypersensitivity to sulfites		Epinephrine allergy	

With respect to drug interactions, caution must be used when administering epinephrine-based anesthetics in those who are taking antidepressants and/or beta-blockers.^{5,6} Epinephrine and propranolol together can result in a life-threatening systemic reaction.^{14,124} The injection of epinephrine in a patient receiving propranolol results in unopposed alpha-1 vasoconstriction activity.¹⁴ This can result in a marked hypertension followed by reflex bradycardia, which ultimately can lead to a cardiac or neurologic event.^{6,14,124} This reaction has been reported to occur with only 8-mL lidocaine with 1:200,000 of epinephrine (a very low systemic dose of epinephrine), in a patient taking Inderal, 60 mg daily.¹²⁴ For smaller dermatologic procedures such as biopsies, this interaction may not be as clinically important.¹⁴ For larger skin surgeries requiring more local anesthesia, it may be advisable to have patients adjust or temporarily wean off their beta-blocker as directed by their primary care physician before the scheduled procedure.¹⁴

Allergic reactions

Types 1 and 4 hypersensitivity reactions to topical and local anesthetics have been reported but are rare.^{6,28} Type 1 reactions are IgE mediated, immediate, and can lead to anaphylaxis.⁵ Ester-derived anesthetics are more often associated with allergic reactions than amide anesthetics.⁵ There is no cross

reactivity between ester and amide reactions.⁶ Ester anesthetics are metabolized to PABA, a common allergen that cross reacts with thiazides, sulfonyleureas, and hair dyes containing paraphenylenediamine (PPD).^{6,111} Amide-induced allergic reactions are rare and are likely due to methylparabens found in the preservative.^{5,108,111} When a patient has a documented history of procaine or PABA sensitivity, the use of preservative-free lidocaine is recommended.^{6,111} If a mild reaction is noted, it can be managed with antihistamines and topical corticosteroids.^{5,6} When anaphylaxis is suspected, it should be quickly addressed by activating EMS and administering 0.3 to 0.5 mg of epinephrine subcutaneously along with basic life-support measures.^{6,125}

There are no specific recommendations to test for allergic reactions to local anesthetics.^{5,111} Some authors advise the use of patch tests or intradermal testing with preservative free lidocaine in high-risk patients.^{6,111} Another option is to avoid local anesthetic agents entirely. Nontraditional anesthetics which have been shown to be effective include ice, normal saline, diphenhydramine 1%, bacteriostatic saline,²⁸ intradermal tramadol, and metoclopramide.^{5,126,127} Shave biopsy sites may be easily anesthetized with normal saline or liquid nitrogen. Diphenhydramine is more sedating^{5,6} and painful¹²⁶ than lidocaine and can rarely lead to skin necrosis.¹²⁷ Intradermal tramadol can induce local-site skin reactions.^{6,128,129} When faced with the dilemma of what is the best anesthetic agent to use in a high-risk patient, it is probably the best to consult with an allergist.^{5,6} In this way, one can most accurately assess the degree and nature of the allergy, attempt to desensitize the patient to that allergen, and identify the safest anesthetic approach for the patient.

Methemoglobinemia

Methemoglobinemia is the process in which hemoglobin is oxidized to a non-oxygen-carrying state instead of oxygen-carrying reduced state.^{5,6} Benzocaine and prilocaine are most often associated with methemoglobinemia.⁶ Infants and children are more susceptible to hemoglobin oxidation given that they may have more susceptible hemoglobin

F, have less reductive enzymes, and a lower body weight.^{5,6,112} Other risk factors for methemoglobinemia include glucose 6-phosphate dehydrogenase deficiency, methemoglobin reductase deficiency, and use of medications such as antimalarials and sulfonamides (Table 12-14).^{5,130} Rare cases have also been reported with EMLA cream.^{5,112}

Table 12-14. Risk Factors Associated with Methemoglobinemia

■ G6PD deficiency
■ Methemoglobin reductase deficiency
■ Infants and children
■ Less reductive enzymes
■ Hemoglobin F susceptibility
■ Lower weight
■ Simultaneous medication ingestion
■ Antimalarials
■ Dapsone
■ Nitrates
■ Phenobarbital
■ Sulfonamides

Table 12-15. Recommended Pediatric Doses for EMLA Cream^a

Age	Weight	Max Dose (g)	Max Application Area (cm ²)	Application Time (hours)
0–3 months	<5 kg	1	10	1
3–12 months	5–10 kg	2	20	4
1–6 years	10–20 kg	10	100	4
7–12 years	20 kg	20	200	4

^aFor applying to intact skin only. Caution must be taken if applying to injured or inflamed skin as EMLA absorption can vary in these areas.

When evaluating and treating methemoglobinemia, it is important to recognize that conventional pulse oximetry is unreliable.^{5,6} The presence of cyanosis without the presence of cardiorespiratory disease is a strong clinical indicator.⁶ Actual blood levels of methemoglobin or arterial blood gases are required for accurate diagnosis.⁶ Methemoglobin levels below 30% can be managed with observation, oxygen, and the elimination of further local anesthetic delivery.^{5,6,125} Higher methemoglobin levels may require IV methylene blue administered at a 1- to 2-mg/kg dose.^{5,6} In those with G6PD

deficiency, methylene blue is contraindicated, though ascorbic acid and/or hemodialysis can be utilized.^{5,6,125,130}

Children

The recommended doses for lidocaine without epinephrine in children over 3 years of age should not exceed 1.5 to 2.0 mg/kg, and with epinephrine 3.0 to 4.5 mg/kg.^{6,14} The use of preservative-free anesthetic is preferred in neonates with jaundice.³⁸ This is due to the intrinsic bilirubin displacement properties of parabens found within preservative-containing anesthetics.

Topical anesthetics can induce toxicity in children, and care must be taken when using these agents.^{5,56} The recommended pediatric doses for EMLA cream can be found in Table 12-15.^{5,53}

Pregnancy considerations

Local anesthetics are generally considered safe during pregnancy, despite the fact that they can cross the placenta via passive diffusion.⁶ Studies have demonstrated safety with first-trimester lidocaine use with no adverse maternal or teratogenic effects.¹²³ Lidocaine, etidocaine, and prilocaine are categorized as Category B drugs.⁶ Bupivacaine and mepivacaine are classified as Category C because of their potential to induce fetal bradycardia.^{6,123} Infant toxicity has also been reported in lactating mothers treated with large volumes of local anesthesia agents.¹²³

PREOPERATIVE, INTRAOPERATIVE, AND POSTOPERATIVE CONSIDERATIONS

Preoperative considerations

Preoperative anxiolytics and pain medications are sometimes used prior to longer dermatologic surgery procedures such as liposuction, laser resurfacing, and/or large flap repairs.⁶ Adjuvant perioperative medications require discussion with the patient before the actual procedure is

performed.^{6,131} The dermatologist must ensure that the patient has a ride to and from the office, review with the patient the need for continuous monitoring, and discuss the potential adverse effects of using anxiolytics and narcotics. The latter risks including somnolence, nausea, amnesia, and drug-induced allergic reactions.

One preoperative cocktail utilizes triazolam 0.25 mg, promethazine 25 to 50 mg, and hydrocodone with acetaminophen (Table 12-16). The patient's history and physical examination, photographs, and informed consents are taken care of ahead of time in a separate preoperative visit. On the day of surgery, the patient is brought into the operative suite where their vital signs and O₂ saturation measurements are taken. If the patient vitals are stable, an anxiolytic, antiemetic, analgesic, or topical anesthetic is given. Within 30 minutes, the patient is usually comfortable to a point where nerve blocks or tumescent anesthesia can be administered.

Table 12-16. Oral Preoperative Regimen Given Prior to Major Skin Surgery

Triazolam 0.25–0.5 mg
Promethazine 25–50 mg
Hydrocodone bitartrate 7.5 mg with acetaminophen 325 mg
Administered 30 minutes before procedure at office if BP and pulse are stable (systemic blood pressure 90–160 mmHg, pulse >50 bpm)

Patients should be instructed preoperatively to have someone drive them to and from the office.

If extensive sedation is required, intravenous midazolam, propofol, and/or fentanyl can be used (Table 12-17).^{6,131,132} In these instances, an anesthesia provider dedicated to patient monitoring should be in place.¹³¹ It is recommended that this provider be a different person than the dermatologic surgeon. A transfer agreement to a nearby hospital should be available and ready to execute in case of an unforeseen emergency. Surgeons and their staff should be well versed in ACLS algorithms,¹³¹ and if any patient complication occurs, for example, drop in blood pressure, low oxygen saturation, arrhythmia, or patient unresponsiveness, the procedure should be

immediately stopped, EMS activation initiated, and ACLS protocols followed.

Table 12-17. Example of an IV Sedation Protocola

Establish an IV line and evaluate the patient with ECG, BP cuff, and O ₂ saturation monitor	
O ₂ administration with a nasal cannula—keep O ₂ Sat >90%	IV infusion of normal saline or lactated Ringer's solution
Midazolam—0.5–2 mg administered over 1–2 minutes, can use up to 0.6 mg/kg in resistant cases, but such doses may prolong recovery, reversible with flumazenil	
Fentanyl 1–2 µg/kg—100–200 mcg bolus followed by 1–2 µg/kg/hr by continuous infusion	
Initiate sedation slowly with a continuous infusion technique to desired level of conscious sedation as measured by the Ramsey scale	
Consider propofol infusion at 25–50 µg/kg/min	
Look for signs of clinical endpoints such as slurred speech, nystagmus. The dosages of the above-mentioned medications may need to be adjusted according to patient's health, age, and desired level of sedation.	

^aA separate provider should administer the anesthesia and transfer agreement should be in place with a nearby hospital in case of an emergency.
Modified with permission from Abeles G, Warmuth IP, Sequeira M, et al: The use of conscious sedation for outpatient dermatologic surgical procedures, *Dermatol Surg.* 2000 Feb;26(2):121–126.

Intraoperative considerations

For short dermatologic procedures, buffered lidocaine 1% with 1:100,000 epinephrine can be used as a solitary anesthetic. With longer cases, such as Mohs surgery and four-lid blepharoplasty surgery, the addition of bupivacaine or etidocaine can be added to maximize the anesthetic duration.^{5,6} For longer surgeries, buffered lidocaine is administered first in order to provide more comfort for the patient prior to injecting bupivacaine, which is a much more painful and slower-acting anesthetic. Anesthetic is drawn up using an 18-gauge syringe and subsequently injected into the skin using a 30-gauge needle.

Cold compresses prior to injection can also serve to alleviate patient discomfort.¹³³ Hemostasis can be optimized by waiting for 5 to 10 minutes post-injection.⁵ For infected sites, larger volumes of local anesthetic may be required because they work less effectively in bacteria- laden acidic environments.⁵

For procedures requiring multiple injections, it is useful to advance the needle in an area that has been previously anesthetized.⁶ Puncture number can be reduced by using longer needles or employing cannulas. Ring blocks are a great consideration for cyst removal, incision and drainage procedures, lipoma removal, and scalp and ear procedures.^{5,6}

For surgeries involving the face, such as laser resurfacing, or the hand, foot, and digits, nerve blocks are ideal.^{5,6,92} They require less anesthetic,

create minimal tissue distortion,^{5,6} and are often less painful. The disadvantages of nerve blocks are that they take time to complete⁵ and do not provide hemostasis.⁶

For larger procedures requiring higher anesthetic volumes, tumescent anesthesia should be utilized, which allows for higher doses of lidocaine to be delivered with minimal toxicity and increased effectiveness.⁵

Concentrations used will vary based on the area and procedure type.⁵ Facelifts and neck liposuction procedures usually require a higher concentration of anesthetic solution, for example, lidocaine 0.3%, whereas abdominal liposuction cases can be effectively performed using much lower concentrations, for example, lidocaine 0.05% to 0.1%.

Topical anesthesia use is especially effective in mucosal areas or prior to pediatric procedures such as wart or molluscum removal.⁵ They can be applied over a treatment site “like cream cheese on a bagel” or under occlusion in limited areas. The removal of skin tags, hemangiomas, and incision and drainage procedures are less painful with topical anesthetic formulations. Combined approaches using topical anesthetics with nerve blocks are a great way to help laser resurfacing and dermabrasion patients achieve optimal comfort without the need for general anesthesia.

Postoperative considerations

Postoperatively, patients have varied pain and anxiolytic needs (Table 12-18).⁶ For standard dermatologic procedures, most individuals do not require systemic narcotics. If patients do experience postoperative pain, cool compresses combined with ibuprofen and acetaminophen can be employed.⁶ One common approach for minor postoperative pain is to have patients alternate acetaminophen with ibuprofen every 4 hours. For extensive skin surgery procedures, patients may require postoperative narcotics such as acetaminophen with codeine and/or hydrocodone.⁶ Pain control is important for both patient and surgeon alike; analgesics help to minimize postoperative bleeding risks that occur with blood pressure spikes that occur when patients are experiencing pain from their surgery.

Table 12-18. Other Postoperative Considerations

- Personally calling the patient to ensure a smooth postoperative course and alleviate any concerns that they may have.
 - Alternate acetaminophen 500–1000 mg with ibuprofen 600 mg every 4 hours.
 - Cool compresses over surgery areas for 5–10 minutes every hour as tolerated.
 - For laser resurfacing cases, mix three parts petrolatum with one part topical anesthetic and to apply this to a completely treated area while the nerve block is still working. Have patients reapply this mixture every 2–3 hours for the first 24 hours.
 - Injecting an additional amount of bupivacaine or tumescent anesthetic solution at the end of the surgery. This will help the patient gain some added pain relief as they wait for their oral pain medication to take effect.
-

For postoperative laser resurfacing cases, mix three parts petrolatum with one part topical anesthetic and apply this to a completely treated area, while the nerve block is still working, for example, complete the laser procedure on one-half of the face and immediately apply the dilute topical anesthetic agent. With this approach, patients leave the office very comfortable. They are advised to reapply this numbing mixture every 2 to 3 hours for the first 24 hours. After this period, patient discomfort is minimal and they usually only complain of warmth and swelling which can be easily managed with cool compresses and oral ibuprofen.

The third postoperative consideration to optimize patient comfort is to inject an additional amount of bupivacaine or tumescent anesthetic solution postoperatively.^{6,80,81} This will help the patient gain some added pain relief while they wait for their oral pain medication to take effect.

SUMMARY

Local anesthesia is a vital part of dermatologic surgery. The correct use and understanding of these agents have helped dermatology patients undergo their procedures in a safe and effective manner without the risks of general anesthesia. Knowledge of how and why we use these medications is of

extreme importance to the dermatologic surgeon. As new scientific breakthroughs occur in the area of local anesthesia and delivery systems, the fruits of this knowledge will hopefully help our specialty advance for the betterment of our patients.

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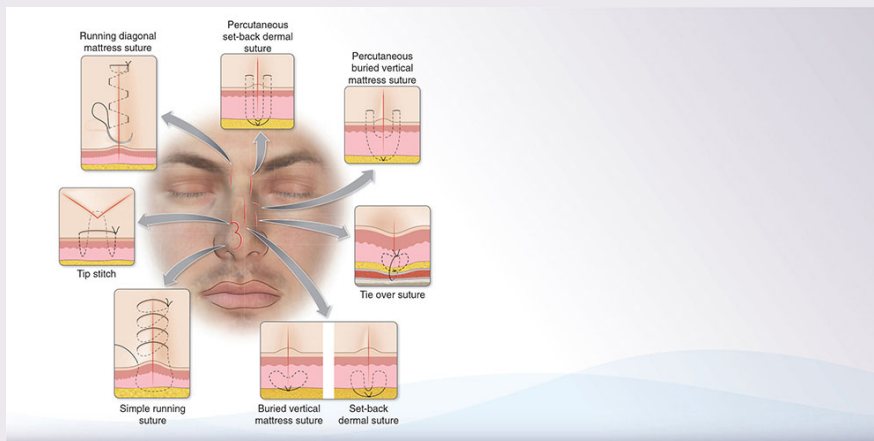
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CHAPTER 13 Suturing Techniques

Jonathan Kantor



SUMMARY

- While most day-to-day procedures demand only a few suturing techniques, recent evidence has suggested that choice of technique has the potential to impact long-term outcomes.
- Suturing techniques can be dichotomized as buried versus transepidermal techniques, though the use of percutaneous approaches may make this distinction unclear.

- While the dermatologic surgeon does not need to incorporate a vast array of techniques into daily practice, precise placement of sutures coupled with an appreciation of the subtle variations in individual patients that may benefit from particular niche techniques is very helpful and may result in improved surgical outcomes.

Beginner Pearls



- Deep suture techniques, such as the buried vertical mattress or set-back dermal suture, are fundamental techniques for all wound closures, as they lead to wound eversion, wound-edge approximation, and shift tension to the dermis.
- Fascial plication sutures are very useful to reduce dead space and reduce tension, and serve to shift tension even deeper, ultimately leading to a possibly improved outcome.

Expert Pearls



- When suturing a tight location, such as the scalp or lower leg, either percutaneous approaches or a buried horizontal mattress suture may be used for the deeper layer of sutures.

- With meticulous suture placement, no transepidermal sutures are needed for many closures, as the deep sutures lead to both tension reduction and wound-edge approximation.

Don't Forget!



- When working on the back, use thicker suture such as a 2-0 absorbable suture with a large needle.
- To reduce the risk of suture material spitting, consider using set-back sutures that leave no suture material at the incised wound edge.

Pitfalls and Cautions



- Pulley variations may be useful for wounds under significant tension, but always using a pulley approach may needlessly increase the amount of suture material left in the wound, leading to an increased risk of foreign body reactions and suture material spitting.
- Fascial plication sutures may increase the risk of pain or infection; if pain after suture placement persists for more than 30 seconds, the suture should be removed.

Patient Education Points



- The dramatic eversion seen after dermatologic surgery should be explained to patients ahead of time and reviewed repeatedly.
- Using the analogy of a subcutaneous splint (or cast) may be helpful when explaining that the goal is to reduce tension temporarily but that the eversion will not persist.

Billing Pearls



- An intermediate or complex repair code is predicated on the wound being closed in a layered fashion.
- Fascial plication followed by dermal sutures would be considered a layered closure for these purposes.

CHAPTER 13 Suturing Techniques

INTRODUCTION

Suturing techniques have seen a renaissance over the past decades, as dermatologic surgeons have increasingly appreciated the impact that precisely placed sutures have on surgical outcomes. The rise of evidence-based medicine has led to a boon in suture technique development, as surgeons have become more willing to consider changing the fundamental techniques that were adopted during training in an effort to provide even better patient outcomes.

Even the best-designed flaps can be undone by less- than-optimal suturing techniques and tissue handling. While most day-to-day procedures demand only a very few suturing techniques, recent evidence has suggested that choice of technique has the potential to impact long-term outcomes.¹

Suturing techniques can be dichotomized as buried versus transepidermal techniques, though the use of percutaneous approaches, discussed in detail below, may make this distinction sometimes unclear. In general, the buried techniques are those that do not require suture removal, while the transepidermal approaches necessitate suture removal unless rapidly absorbing suture materials are used.

BURIED SUTURE TECHNIQUES

The buried vertical mattress suture

This technique is a common approach widely utilized by dermatologists and plastic surgeons (Figs. 13-1 through 13-3).²

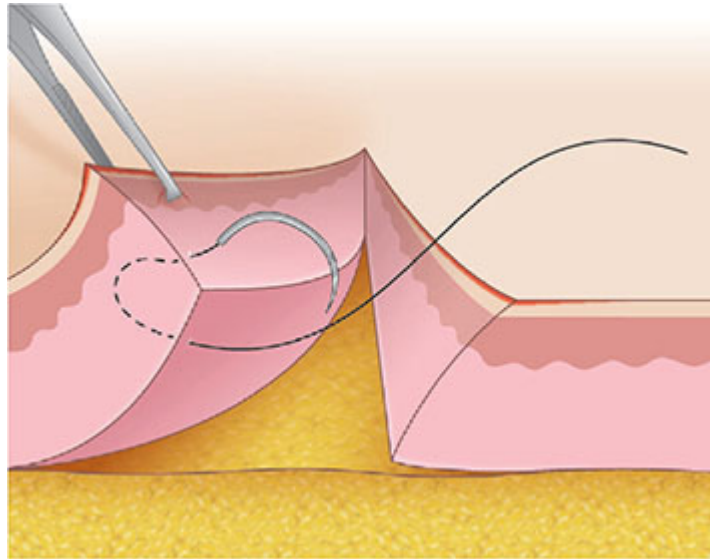


Figure 13-1. The needle is inserted through the underside of the dermis and moves upwards and outwards in the dermis before returning to exit at the incised wound edge.

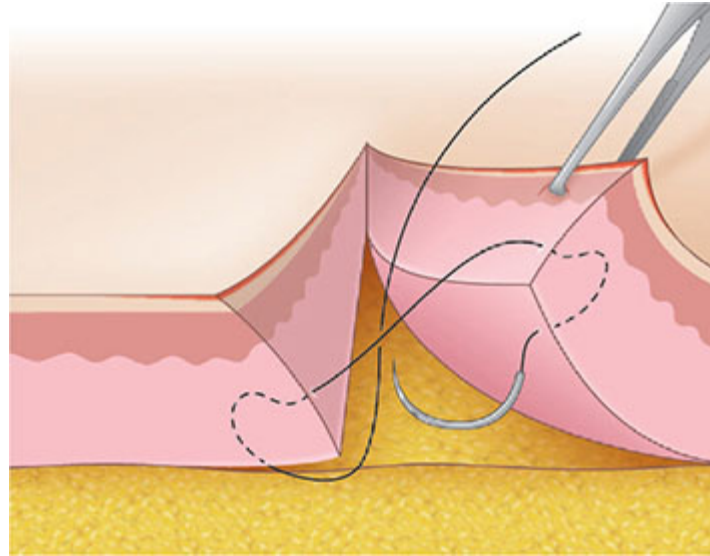


Figure 13-2. The needle is then inserted through the incised wound edge before moving upwards and outwards away from the wound edge and exiting in the deeper dermis.

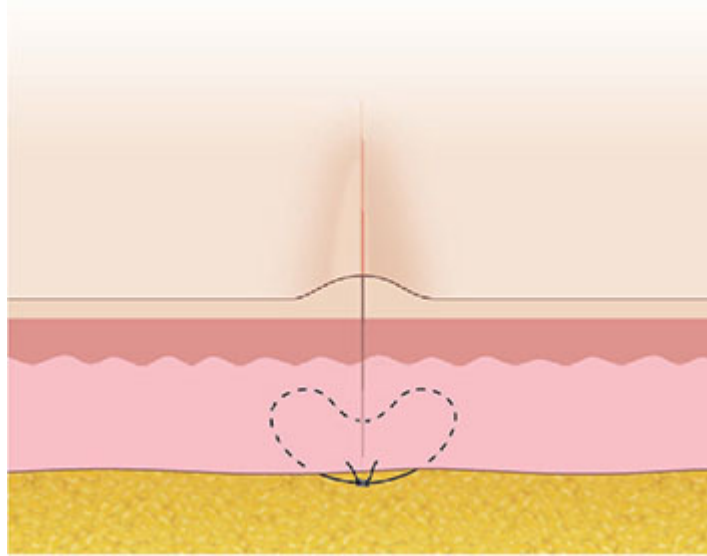


Figure 13-3. Lateral view of the buried vertical mattress suture highlighting the heart-shaped path the suture material takes through the dermis.

Buried Horizontal Mattress Suture Step-by-Step

- a. The wound edge is reflected back using surgical forceps or hooks. Adequate visualization of the underside of the dermis is desirable.
- b. While reflecting back the dermis, the suture needle is inserted into the undersurface of the dermis parallel to the surface of the skin just lateral to the incised wound edge.
- c. The first bite is executed by placing gentle pressure on the needle so that it enters the papillary dermis and the relaxing pressure to permit the needle to exit on the undersurface of the dermis.
- d. Keeping the loose end of suture between the surgeon and the patient, the dermis on the side of the first bite is released. The tissue on the opposite edge is then reflected back in a similar fashion as on the first side.
- e. The second and final bite is executed by inserting the needle into the undersurface of the dermis on the contralateral side, with a backhand technique if desired, and completing a mirror-image loop, so that the needle exits directly across from its original entry point on the contralateral side.
- f. The suture material is then tied utilizing an instrument tie.

It requires some practice to master, though once mastered it is straightforward to execute. The first bite may also be finessed by first reflecting the wound edge back sharply during needle insertion and then returning the edge medially after the apex has been reached. This approach helps to lead the needle in the correct course without an exaggerated change in direction with the needle driver.

When suturing, both the obviously active element (the needle and needle driver, held by the dominant hand) and the ostensibly passive element (the skin, held by forceps or a skin hook) have the potential to move in three dimensions. Thus changing the way the needle moves through the skin can be accomplished by either adjusting the way the needle is moved through the skin with the dominant hand, adjusting how the skin is held or manipulated by the other hand, or a combination of the two. With experience, a combination is often more effective at affecting the vertical mattress suture in an elegant and efficient fashion.

The apex of the needle should be in the papillary dermis; if the needle courses too superficially, dimpling may occur. This technique, if executed appropriately, leads to both excellent wound eversion and outstanding wound-edge approximation.

The set-back dermal suture

This approach is frequently used in areas under significant tension, and as an alternative to the buried vertical mattress as a standard buried technique.³ Since it is easier to place than a buried vertical mattress suture, this technique may be used by budding surgeons, medical students, and residents as the workhorse technique for deep tension-relieving sutures (Figs. 13-4 through 13-6).

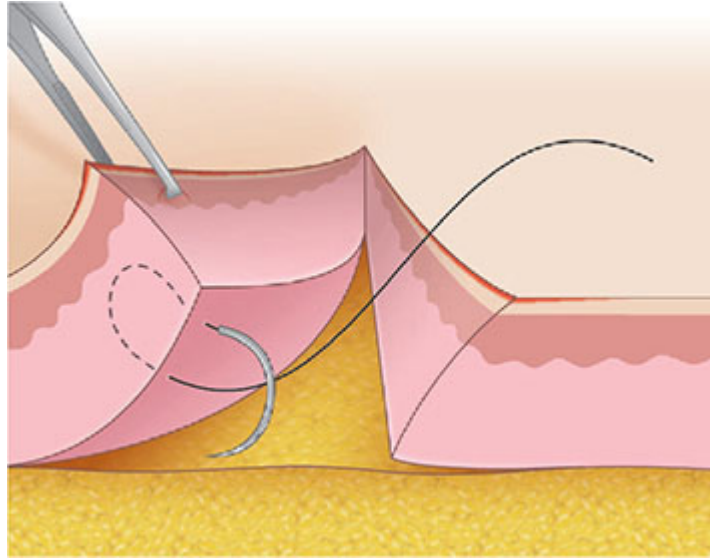


Figure 13-4. The needle is inserted through the underside of the dermis, exiting again through the underside of the dermis set back from the wound edge.

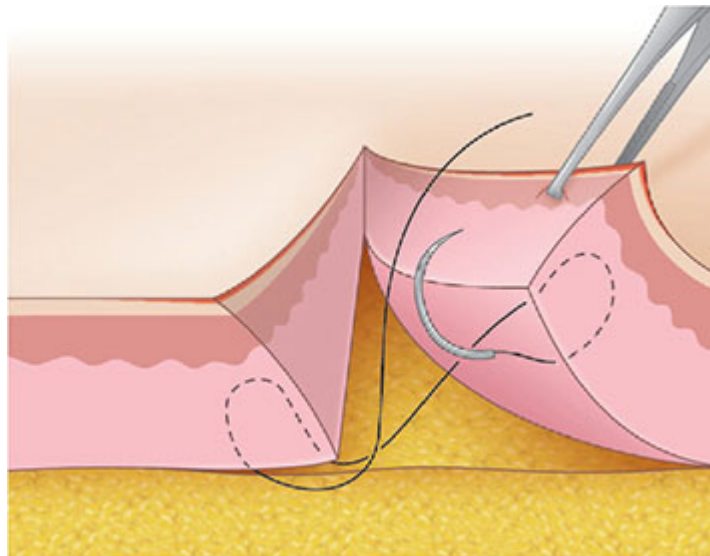


Figure 13-5. This is repeated on the contralateral wound edge.

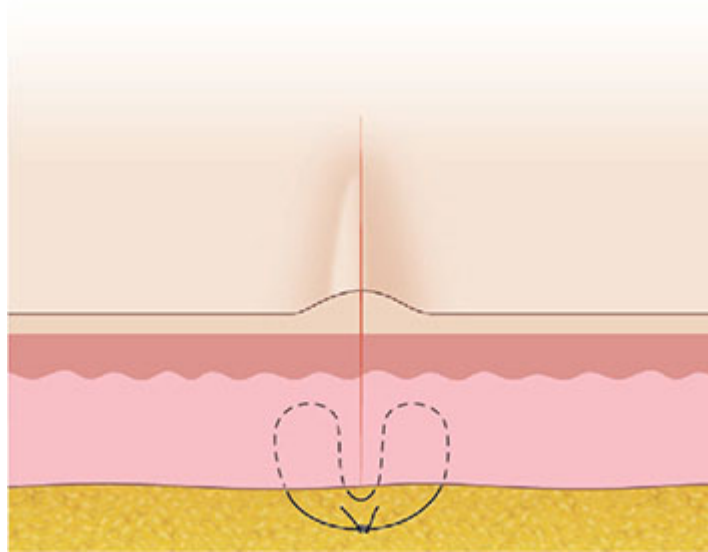


Figure 13-6. Cross-sectional view demonstrating the path of the suture material through the dermis and the effect on wound eversion.

The Set-back Dermal Suture Step-by-Step

- a. The wound edge is reflected back using surgical forceps or hooks. Adequate visualization of the underside of the dermis is required.
- b. While reflecting back the dermis, the suture needle is inserted at 90 degrees into the underside of the dermis 2 to 6 mm distant from the incised wound edge.
- c. The first bite is executed by traversing the dermis following the curvature of the needle and allowing the needle to exit closer to the incised wound edge. Care should be taken to remain in the dermis to minimize the risk of epidermal dimpling. The needle does not, however, exit through the incised wound edge, but rather 1 to 4 mm distant from the incised edge. The size of this first bite is based on the size of the needle, the thickness of the dermis, and the need for and tolerance of eversion.
- d. Keeping the loose end of suture between the surgeon and the patient, the dermis on the side of the first bite is released. The tissue on the opposite edge is then reflected back in a similar fashion as on the first side, assuring complete visualization of the underside of the dermis.

- e. The second and final bite is executed by inserting the needle into the underside of the dermis 1 to 6 mm distant from the incised wound edge. Again, this bite should be executed by following the curvature of the needle and avoiding catching the undersurface of the epidermis that could result in epidermal dimpling. It then exits further distal to the wound edge, approximately 2 to 6 mm distant from the wound edge. This should mirror the first bite taken on the contralateral side of the wound.
- f. The suture material is then tied utilizing an instrument tie.

This technique was compared with the buried vertical mattress suture in a randomized trial and was found to be superior to in terms of eversion and cosmetic outcomes based on both physician and patient assessments.¹

One of the chief advantages of this technique is its ease of execution; since the suture follows the arc of the needle on the undersurface of the dermis, there is no need to change planes, affect a heart-shaped suture placement, or guarantee that the suture exit point is precisely at the inside edge of the lower dermis, as may be needed with the buried vertical mattress suture.

Accurate suture placement is predicated on having a sufficiently undermined plane, since the entire suture loop lays on the undersurface of the dermis. Therefore, broad undermining is a prerequisite for utilizing this technique, since the first throw of the needle begins 2 to 6 mm distant from the incised wound edge.

This technique may also be used to minimize dead space when excising a space-occupying lesion such as a cyst or lipoma. In this event, taking the first bite set-back even further from the incised wound edge will translate into a larger ridge and will simultaneously minimize the laxity in the central portion of the wound as the dermis is pulled taught so that potential dead space is converted to a hyper-everted wound ridge which will absorb with time.

Patients should be cautioned that they might develop a significant ridge in the immediate postoperative period. Depending on the suture material used and the density of the sutures, this ridge may last from weeks to months. Explaining that the technique is akin to placing a subcutaneous splint may help the patient develop reasonable and realistic expectations and reduce anxiety regarding the immediate postoperative appearance of the wound.⁴

A possible complication of hypereversion and an overly broad bite is that the raised ridge may be too large or bulky to be supported by the deep sutures.⁵ In this event, the wound edges may paradoxically collapse centrally leading to the appearance of a dramatically raised ridge with a central valley approximately 1 week postoperatively. As the sutures absorb over time, this will yield a depressed or inverted scar line. This can generally be avoided by not setting back the sutures more than a few millimeters from the wound edge and by placing a sufficient number of sutures so that the body of the ridge may be easily supported.

Suspension suture

This is a niche technique designed to fix one or both edges of a defect to a deeper structure. This approach has also been referred to as a pexing suture or tacking suture, and is utilized typically in several situations. First, when repairing a defect that crosses a natural sulcus, it is important to tack down the skin overlying the sulcus so that the natural depression is not blunted, or bridged, by the repair. Second, it is used when working near cosmetic subunit boundaries and free margins, to avoid functional challenges such as ectropion and eclabium, as well as cosmetic distortion of sensitive areas such as the lip and eyebrows. It is also useful in order to fix a flap in place and minimize tension on the distal portion of the flap. Finally, this approach may also be used to prevent nasal valve collapse in the appropriate setting (Fig. 13-7).

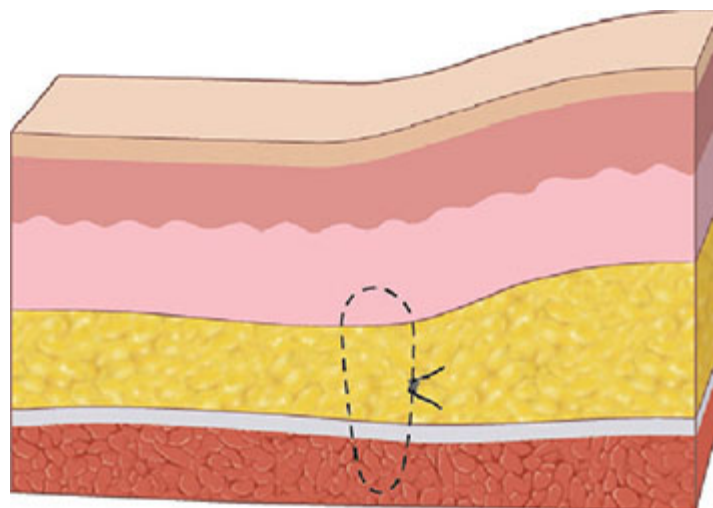


Figure 13-7. Overview of the suspension suture technique.

Suspension Suture Step-by-Step

- a. First, the surgeon determines the desired location for fixing the suspension suture, as discussed below. The wound edge is reflected back using surgical forceps or hooks, and adequate visualization of the underside of the dermis is desirable.
- b. While reflecting back the dermis, the suture needle is inserted at 90 degrees into the underside of the dermis 2 to 6 mm distant from the incised wound edge.
- c. The first bite is executed by traversing the dermis following the curvature of the needle and allowing the needle to exit closer to the incised wound edge. This will minimize the risk of vascular compromise. Care should be taken to remain in the dermis to minimize the risk of epidermal dimpling. The needle does not, however, exit through the incised wound edge, but rather 1 to 4 mm distant from the incised edge, or, in select cases, potentially further back from the wound edge.
- d. The flap of skin may be gently pulled by the suture material so that the location of the first bite directly overlies the planned fixation point. This permits the surgeon to double-check the final position of the suspension suture. The needle is then blindly inserted through the fat and deeper structures until bone is reached. A 3-mm bite of periosteum is then taken, and the needle is brought back up through the soft tissues into the open center of the wound.
- e. The suture material is then tied utilizing an instrument tie. Hand-tying may be utilized as well, which may be useful if the depth of the defect is significant.

This technique is very useful when working around the eyelids and lips, though its use demands familiarity with the underlying anatomy so that no sensitive deeper structures are injured or entrapped during the blind placement of the deep anchoring suture. The deep suture should also be placed parallel to the underlying vascular plexus to similarly mitigate this risk.

Placement is based on several considerations, including the degree of tension across the advanced tissue, the presence of a bony prominence, which can be used easily for suspension purposes, and the absence of underlying nerves, which could inadvertently become strangulated by the anchoring suture.

Pulling on the suture once it is anchored to the periosteum may help assure the surgeon that the suture is indeed tacked down to an immobile surface.

A three-point variation of this approach is possible as well, which allows wound-edge approximation and a tacking effect to occur all with one suture placement. This is accomplished by first placing either a buried vertical mattress or set-back dermal suture at the two wound edges and then taking a bite of the underlying periosteum prior to tying the knot. The suture material thus fixes the wound edges together as well as to the underlying anchoring point. This approach, however, may result in suboptimal wound-edge eversion and places additional stress on the suture material, increasing the risk of scar spread. Moreover, it is only appropriate if the anchor target lies in the approximate midpoint of the defect, since it recreates a natural sulcus but does not permit differential pull from one side of the defect.

This technique may also be used as an alternative to cartilage grafting when reconstructing the nose. Loss of alar cartilage may lead to nasal valve collapse, which traditionally was addressed by placing an auricular cartilage graft along the reconstructed alar rim in order to maintain valve patency. A simple and elegant alternative places a suture in the ala and fixes it to a point superolaterally in the maxillary periosteum, permitting the nasal valve to remain open and potentially obviating the need for a cartilage graft. Since the underside of the dermis is tacked to periosteum, this technique may result in an area of depression at the site of suspension suture placement.

Buried horizontal mattress suture

This is a niche technique, useful when closing narrow wounds or those where there is limited space to insert the needle driver, and when placing a buried suture is desirable. It may be employed in a variety of locations, including the scalp, ears, and lower leg (Figs. 13-8 and 13-9).

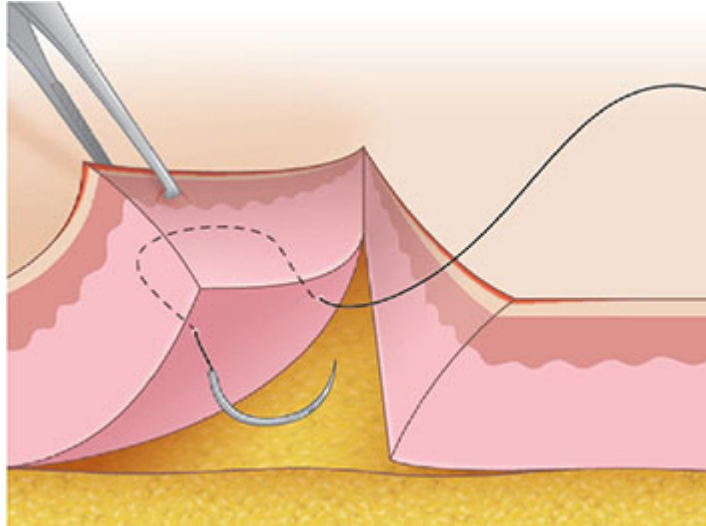


Figure 13-8. The needle is inserted through the dermis running parallel to the incised wound edge.

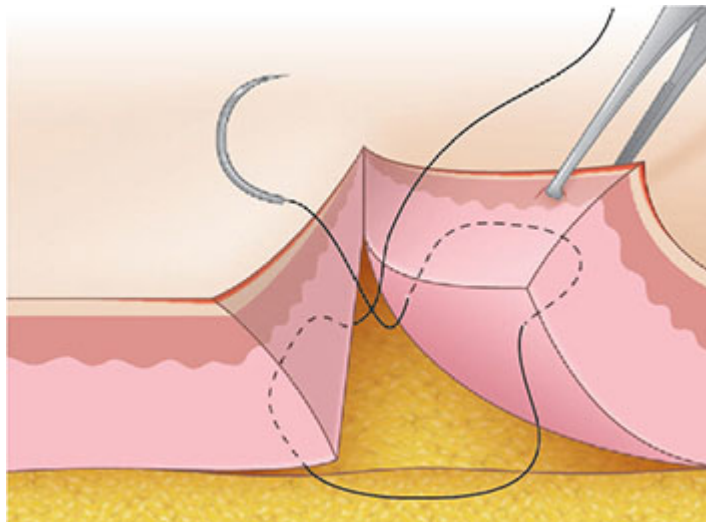


Figure 13-9. This procedure is then reversed on the contralateral wound edge.

Buried Vertical Mattress Suture Step-by-Step

- a. The wound edge is reflected back using surgical forceps or hooks. Adequate visualization of the underside of the dermis is desirable.
- b. While reflecting back the dermis, the suture needle is inserted at 90 degrees into the underside of the dermis 4 mm distant from the incised wound edge.

- c. The first bite is executed by following the needle initially at 90 degrees to the underside of the dermis and then, critically, changing the direction by twisting the needle driver so that the needle exits in the incised wound edge. This allows the apex of the bite to remain in the papillary dermis while the needle exits in the incised wound edge at the level of the reticular dermis.
- d. Keeping the loose end of the suture between the surgeon and the patient, the dermis on the side of the first bite is released. The tissue on the opposite edge is then reflected back in a similar fashion as on the first side.
- e. The second and final bite is executed by inserting the needle into the incised wound edge at the level of the reticular dermis. It then angles upwards and laterally so that the apex of the needle is at the level of the papillary dermis. This should mirror the first bite taken on the contralateral side of the wound.
- f. The suture material is then tied utilizing an instrument tie.

This technique is useful for narrow or shallow wounds, such as those on the scalp and shins.⁶ It may also be used when adding an additional buried suture in an otherwise largely closed wound, where there is insufficient space to insert a vertically oriented buried suture in the narrow space between two other already-placed sutures.

The needle driver may also be held like a pencil, and the needle may then be rotated through the dermis while reflecting back with the forceps to permit easy visualization.

Wound-edge necrosis has been raised as a potential risk of horizontally oriented suture placement, but in practice, this is only encountered very rarely and as a complication of tightly placed traditional horizontal mattress sutures, rather than with the buried equivalent. This is likely due to a constrictive effect on the incised wound edge, which is not typically seen with buried sutures.

Fascial plication suture

This technique is designed for wounds under marked tension, especially those on the back and shoulders. It can also be used for facial repairs, where

grasping the superficial musculoaponeurotic system (SMAS) with this deep suture technique leads to a dramatic reduction in wound size. It is a deep technique, permitting the tension of wound closure to shift from the dermis to the fascia, and concomitantly creating a lower-tension closure. In addition to tension reduction, this approach also leads to an increase in the apparent length-to-width ratio of a fusiform closure and improved dead-space minimization (Fig. 13-10).

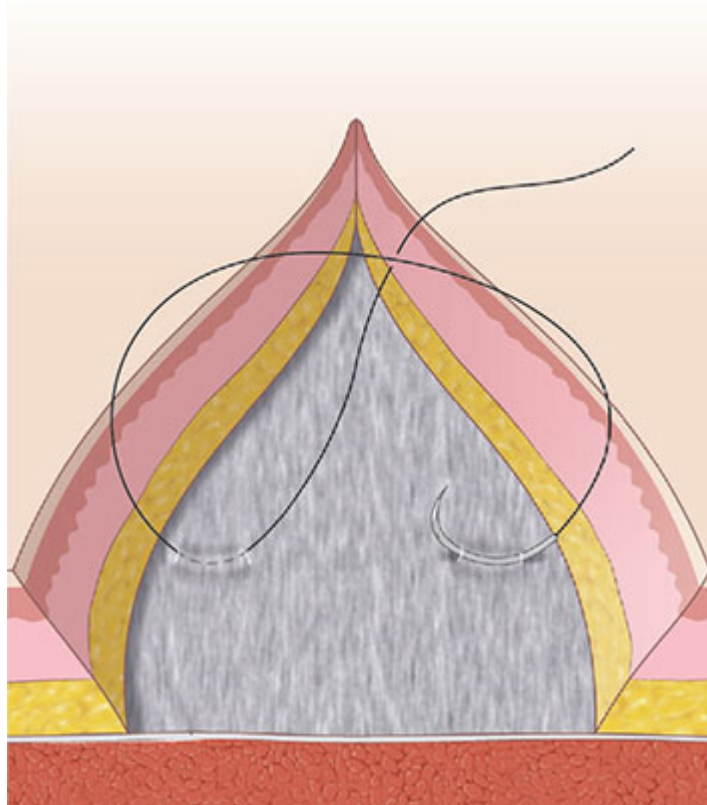


Figure 13-10. Overview of the fascial plication suture technique. Note that the fascial bites may also be taken parallel to the incised wound edges.

Fascial Plication Suture Step-by-Step

- a. The wound edges are reflected back to permit visualization of the deep bed of the wound. In deep excisions, such as those performed for melanoma or large cysts, the muscle fascia may be directly visible. Otherwise, visualizing the subcutaneous fat is appropriate as well.

- b. The suture needle is inserted at 90 degrees through the deep fat 2 to 4 mm medial to the lateral undermined edge of the wound.
- c. The first bite is executed by entering the fascia and following the curvature of the needle. The suture material may be gently pulled to test that a successful bite of fascia has been taken.
- d. Keeping the loose end of suture between the surgeon and the patient, attention is then shifted to the opposite side of the wound. The second bite is executed by repeating the procedure on the contralateral side.
- e. The suture material is then tied utilizing an instrument tie. Hand-tying may be utilized as well, particularly if the wound is deep and the instruments cannot be easily inserted to complete the tie.

This technique is very useful for wounds under marked tension, especially for large defects on the back and shoulders.^{7,8} Even a deep, gaping wound can be converted into a manageable fusiform defect with a single well-placed fascial plication suture. It can, therefore, be conceptualized as an alternative to pulley sutures that affords both a decrease in tension across the wound surface (by shifting tension from the dermis to the fascia) and an increase in the length-to-width ratio of the ellipse.

Indeed, this approach often leads to a more fusiform defect, even when an oval-shaped excision has been performed. Therefore, it may be useful when attempting to keep a defect as short as possible without dog-ear formation. In cases where this approach is anticipated, it may be worthwhile to create a defect with a length-to-width ratio of less than 3 to 1, as is traditionally employed, as that may be sufficient to lead to a tapered ellipse.

Fascial plication sutures need not be used for all linear closures. This technique is most appropriate for areas under significant tension, or large excisions where minimizing the postoperative wound length is desirable. On the face, recruiting the SMAS may be very helpful. When designing the closure of a round defect, the fascial plication suture should be placed prior to removing the dog ears. The risks of fascial plication sutures include possible pain, a theoretically increased infection risk (since the fascial envelope has been pierced by suture), and a theoretical risk of vascular compromise through inadvertent pressure-induced ligation of perforating vessels. In practice, these complications are infrequent, though patients may experience transient pain during needle entry and immediately after the

fascial plication suture is tied. If pain persists for more than 5 minutes, the suture should be removed.

Buried purse-string suture

This technique is designed to either shrink the size of a defect or obviate it entirely, depending on the degree of tension and the size of the defect. The purse-string effect tends to lead to a slight puckering in the surrounding skin, a feature that may be acceptable (and will likely resolve with time) on areas such as the forearms and back, but is less desirable in cosmetically sensitive locations such as the face. The running nature of the technique means that compromise at any point in the course of suture placement may result in wound dehiscence, though for this reason a larger gauge suture material is generally utilized (Fig. 13-11).

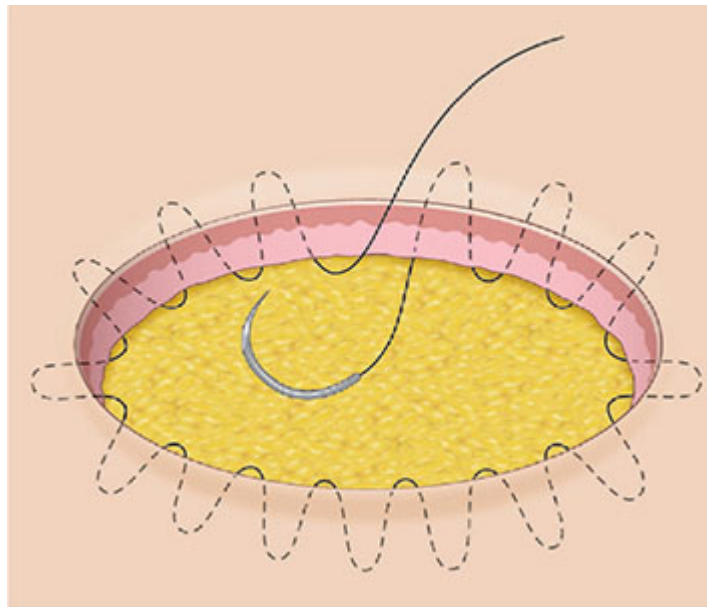


Figure 13-11. Overview of the buried purse-string suture technique.

Buried Purse-string Suture Step-by-Step

- a. The wound edge at the far end of the round- or oval-shaped wound, parallel to the incision line, is reflected back.

- b. With the tail of the suture material resting between the surgeon and the far end of the wound, the needle is inserted into the underside of the dermis on the far edge of the wound with a trajectory running parallel to the incision. In general, this entry point in the dermis should be approximately 3 to 6 mm set back from the epidermal edge, depending on the thickness of the dermis and the anticipated degree of tension across the closure. The needle, and therefore the suture, should pass through the deep dermis at a uniform depth. Bite size is dependent on the needle size; though in order to minimize the risk of necrosis, it may be prudent to restrict the size of each bite. The needle should exit the dermis at a point equidistant from the cut edge from where it entered.
- c. The needle is then grasped with the surgical pickups and simultaneously released by the hand holding the needle driver. As the needle is freed from the tissue with the pickups, the needle is grasped again by the needle driver in an appropriate position to repeat the above step to the left of the previously placed suture.
- d. A small amount of suture material is pulled through and the needle is inserted into the dermis to the left of the previously placed suture, and the same movement is repeated.
- e. The same technique is repeated moving stepwise around the entire wound until the needle exits close to the original entry point at the far end of the wound.
- f. Once the desired number of throws has been placed, the suture material is then pulled taught, leading to complete or partial closure of the wound, and tied utilizing an instrument tie.

This technique is designed as an efficient method of wound area reduction. In many cases, placing a purse-string suture can affect complete wound closure and it therefore represents an alternative to a layered repair of a fusiform incision.

It has been suggested that some defects on the back and extremities, particularly in elderly patients with loose skin, are better closed with a purse-string approach than with a traditional linear closure, since linear closures often heal with a residual scar and require a significantly longer excision line, while the puckering that may be present immediately postoperatively with purse-string closures is likely to resolve with time.⁹⁻¹⁴

That said, in the right hand, linear closures on the trunk and extremities often heal with subtle scarring, even when wounds are closed under tension.

On a pragmatic level, this approach is generally utilized when either a patient is unwilling to undergo a traditional linear closure or when their comorbidities make the additional length of the incision for a linear closure an unrealistic option.

As with linear running dermal techniques, this technique may be used as a modified winch or pulley suture, since the multiple loops help to minimize the tension across any one loop and permit closure of wounds under marked tension. Because each throw is not tied off, it is important to adequately secure the knot.

As with other running dermal techniques, this approach leaves a fair amount of absorbable suture material in the dermis. Therefore, foreign-body reactions, suture abscess formation, and infection are possibilities. That said, since the entire suture line is secured with a single knot, and since most of the bulk of any suture line is in the knots, rather than the lengths of suture material between knots, this technique may be less susceptible to suture abscess or suture spitting than others.

The pucker effect of this closure resolves rapidly in atrophic skin, though it can persist in other areas; patients should realize that some degree of residual puckering toward the center of the wound is to be expected. Additionally, this technique may be used to help recreate the nipple–areola complex if full reconstruction is not desired and the nipple is lost to a local tumor.

Since the entire closure is held by a single knot, this approach may be associated with a higher rate of wound dehiscence, as knot failure in the suture material at any point leads to an immediate loss of tension on the closure. Given the concern regarding knot breakage, it may be helpful to attempt to better secure the knot. This may be done by paying particularly close attention to knot tying, tying an extra full knot, adding extra throws, or leaving a longer tail than would traditionally be executed.

A recent study has suggested, however, that the postoperative cosmesis of a purse-string closure is no better than a wound allowed to heal with secondary intention healing.¹⁵

VARIATIONS

Pulley variations

Pulley (or double) variations are available for most buried suturing techniques. Typically, pulley variations confer two central advantages: they permit the closure of high-tension wounds, where the mechanics of a pulley allow straightforward wound-edge approximation, and they typically lock in place immediately, obviating the need for an assistant. Frequently used approaches include the pulley buried vertical mattress suture (Figs. 13-12 through 13-15)¹⁶⁻¹⁹ and the pulley set-back suture (Figs. 13-16 through 13-19).²⁰

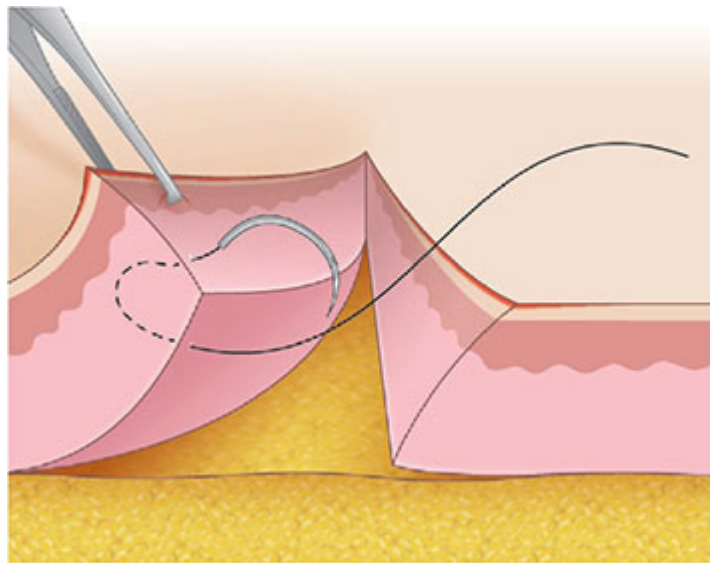


Figure 13-12. The pulley buried vertical mattress suture. The needle is inserted through the dermis, angling upwards and outwards before exiting at the incised wound edge.

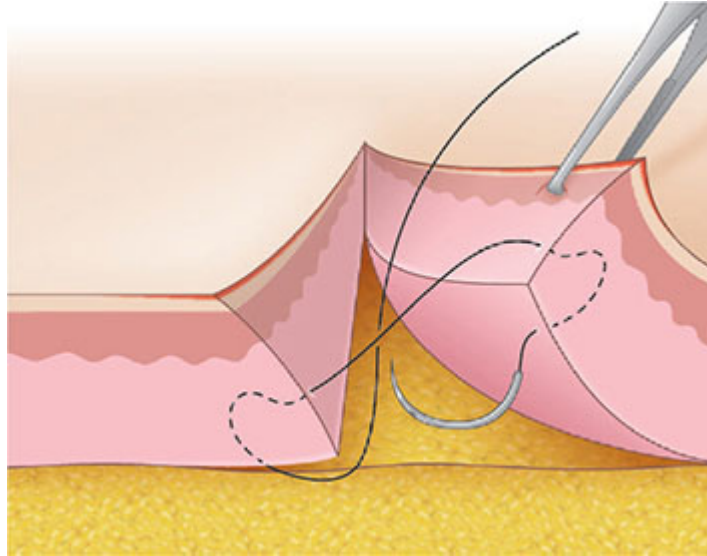


Figure 13-13. The needle is then inserted through the incised wound edge on the contralateral side, again moving superolaterally before exiting deep.

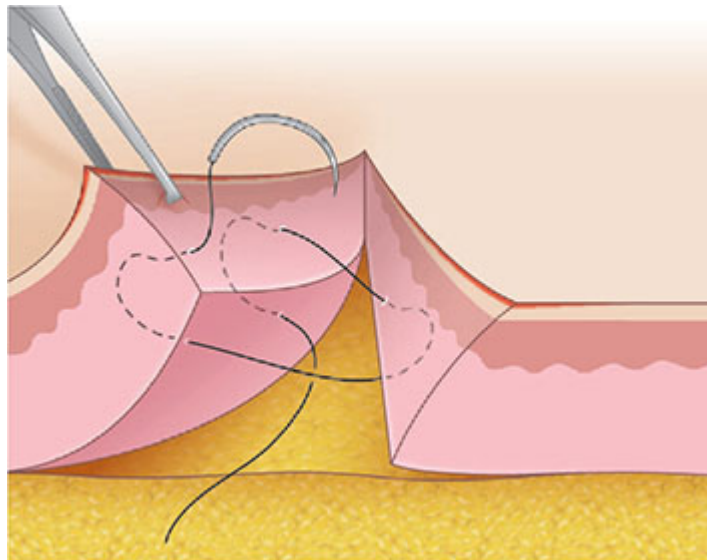


Figure 13-14. Keeping the tail of the suture deep to the suture throws and toward the surgeon, the first step is then repeated, with the needle entering deep and exiting at the incised wound edge.

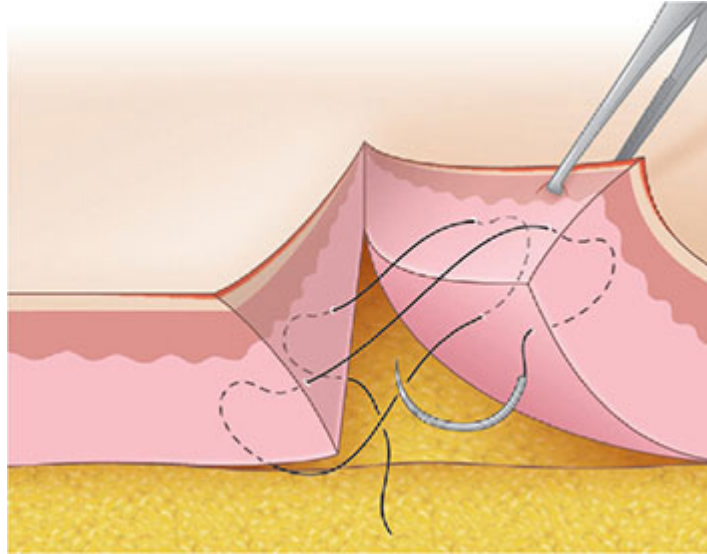


Figure 13-15. Again with the tail deep, the needle is inserted through the incised wound edge on the contralateral side.

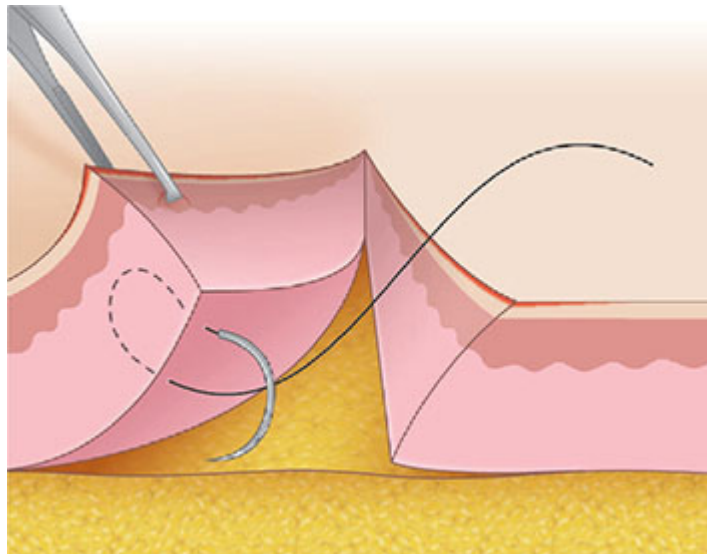


Figure 13-16. The pulley set-back dermal suture. The needle is inserted through the underside of the dermis, exiting the underside of the dermis closer to the incised wound edge but still set back from the incised wound edge.

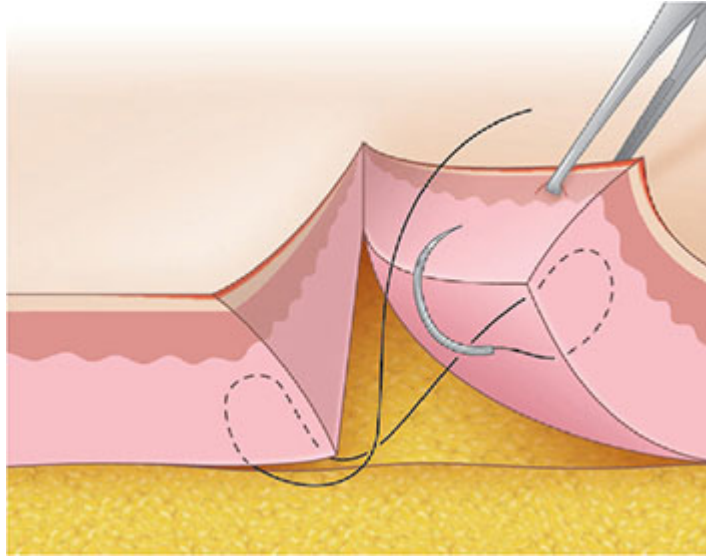


Figure 13-17. The needle is then inserted through the underside of the dermis on the contralateral wound edge, exiting further away from the incised wound edge on the undersurface of the dermis.

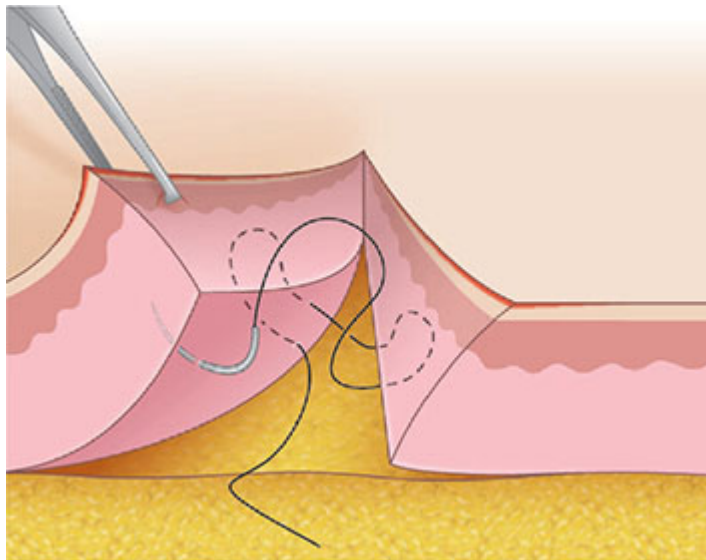


Figure 13-18. With the loose end of the suture material deep to the active sutures and resting between the surgeon and the needle driver, the needle is then reinserted through the undersurface of the dermis.

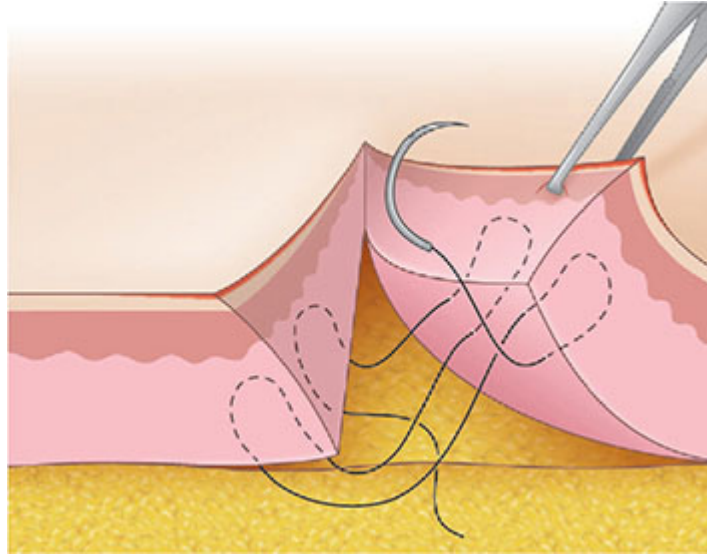


Figure 13-19. The procedure is again repeated on the contralateral wound edge.

Running variations

Running variations of buried sutures permit rapid placement of a long row of buried sutures that are anchored by knots at either end. The speed advantage is offset, however, by the reliance on only two anchor points along an entire wound. Since buried sutures are designed to bear the tension across a wound, relying on a single anchoring suture knot at each end of the wound may be unwise, as break in suture material anywhere along the suture line (or knot compromise at either end) may result in catastrophic consequences.

Percutaneous variations

When placing sutures in narrow areas, percutaneous approaches allow the placement of buried sutures when only minimal visualization is possible. This is particularly useful on the tight skin of the scalp, and when executing narrow closures on the nose and below the knee. Approaches include the percutaneous buried vertical mattress (Fig. 13-20), the percutaneous set-back suture (Fig. 13-21), and the percutaneous horizontal mattress suture (Fig. 13-22).

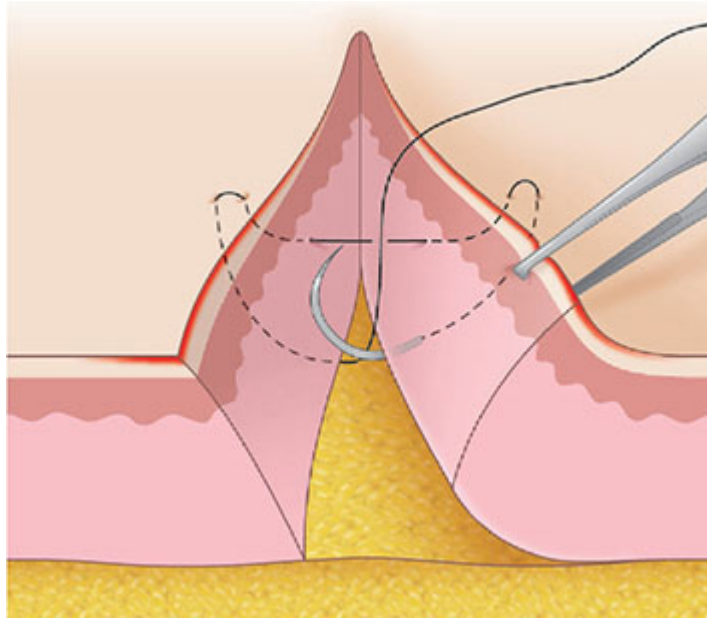


Figure 13-20. The percutaneous buried vertical mattress suture.

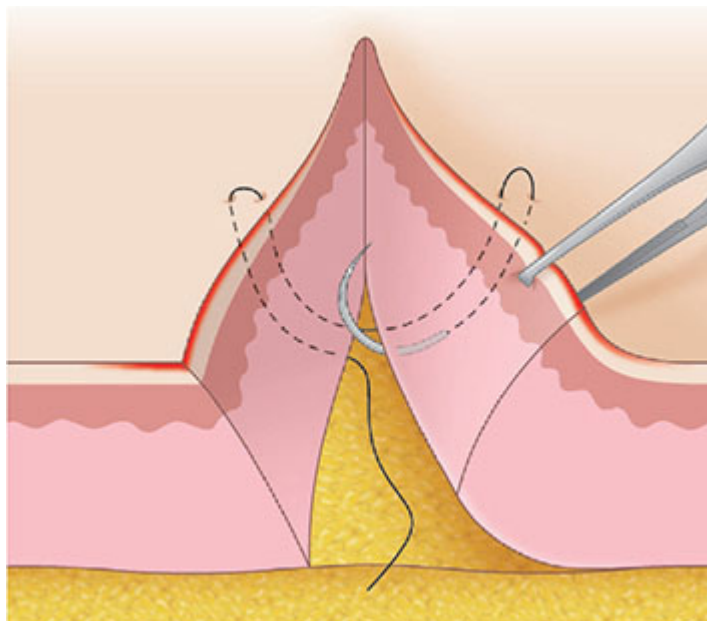


Figure 13-21. The percutaneous set-back suture technique.

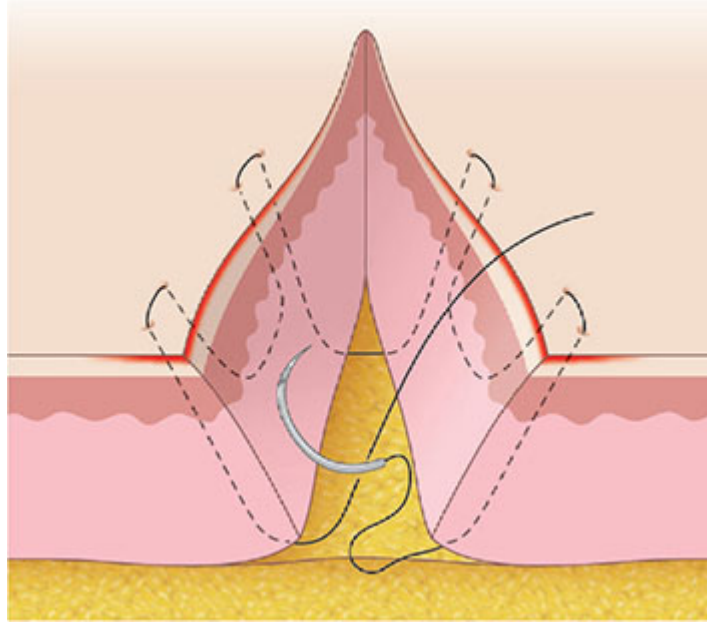


Figure 13-22. The percutaneous horizontal mattress suture technique.

TRANSEPIDERMAL SUTURE TECHNIQUES

The simple interrupted suture

This is the standard benchmark suture used for closure and epidermal approximation. It may be used alone in the context of small wounds under minimal to no tension, such as those formed by either a small punch biopsy or a traumatic laceration. It is also frequently used as a secondary layer to aid in the approximation of the epidermis when the dermis has been closed using a dermal or other deep suturing technique (Fig. 13-23).

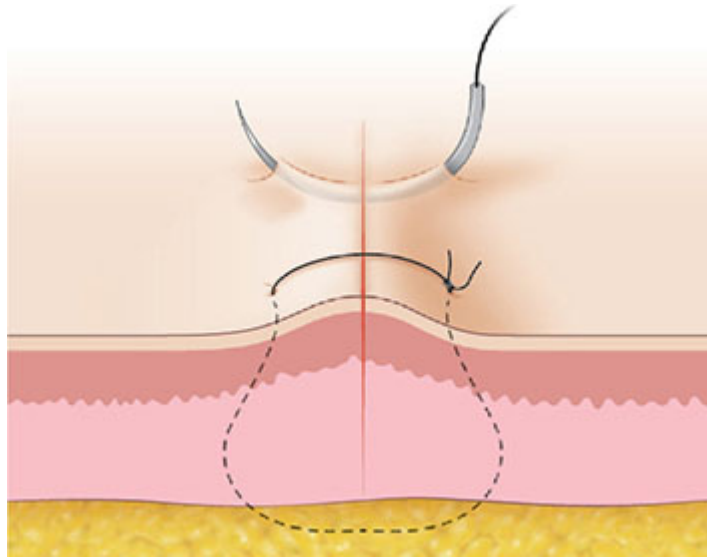


Figure 13-23. Overview of the simple interrupted suture technique.

The Simple Interrupted Suture Step-by-Step

- The needle is inserted perpendicular to the epidermis, approximately one-half the radius of the needle distant to the wound edge. This will allow the needle to exit the wound on the contralateral side at an equal distance from the wound edge by simply following the curvature of the needle.
- With a fluid motion of the wrist, the needle is rotated through the dermis, taking the bite wider at the deep margin than at the surface, and the needle tip exits the skin on the contralateral side.
- The needle body is grasped with surgical forceps in the left hand, with care being taken to avoid grasping the needle tip, which can be easily dulled by repetitive friction against the surgical forceps. It is gently grasped and pulled upwards with the surgical forceps as the body of the needle is released from the needle driver. Alternatively, the needle may be released from the needle driver and the needle driver itself may be used to grasp the needle from the contralateral side of the wound to complete its rotation through its arc, obviating the need for surgical forceps.
- The suture material is then tied off gently, with care being taken to minimize tension across the epidermis and avoid overly constricting the

wound edges.

It is important to enter the epidermis at 90 degrees, allowing the needle to travel slightly laterally away from the wound edge before fully following the curvature of the needle when utilizing this technique. This will allow for maximal wound eversion and accurate wound-edge approximation. The final cross-sectional appearance of the needle's course should be a flask-like shape, wider at the base than at the surface.

Care should be taken to avoid skimming the needle superficially beneath the epidermis. This results from failing to enter the skin at a perpendicular angle and failing to follow the curvature of the needle. This may result in wound inversion as the tension vector of the shallow bite pulls the wound edges outwards and down.

This technique may elicit an increased risk of track marks, necrosis, and other complications when compared with techniques that do not entail suture material traversing the scar line, such as buried or subcuticular approaches. Therefore, sutures should be removed as early as possible to minimize these complications, and consideration should be given to adopting other closure techniques in the event that sutures will not be able to be removed in a timely fashion. Some studies have also demonstrated an increased rate of dehiscence when utilizing interrupted sutures alone without underlying dermal tension-relieving sutures, highlighting that this technique should be used either for wounds under minimal tension or in concert with deeper tension-relieving sutures.²¹⁻²⁶

Vertical mattress suture

This is a frequently used everting technique for closure and epidermal approximation (Fig. 13-24).

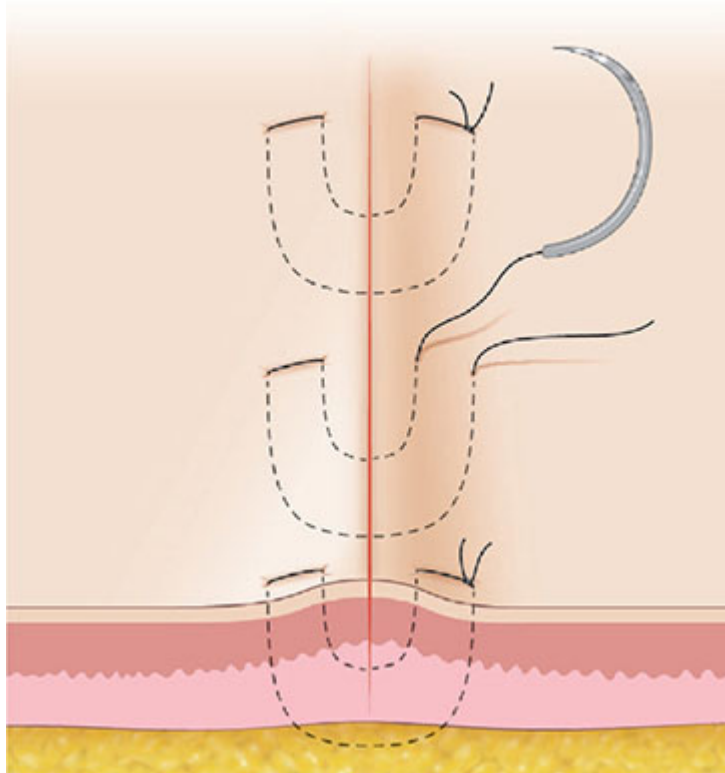


Figure 13-24. Overview of the vertical mattress suture.

This technique is generally used for its pronounced effect on wound eversion. Therefore, while it is appropriate for most skin closures, it should be avoided when either inversion is desired or when exaggerated eversion has already been accomplished with a buried suture.²⁷⁻²⁹

Vertical Mattress Suture Step-by-Step

- a. The needle is inserted perpendicular to the epidermis, approximately 6 mm distant to the wound edge.
- b. With a fluid motion of the wrist, the needle is rotated through the dermis, taking the bite wider at the deep margin than at the surface, and the needle tip exits the skin on the contralateral side. (If the needle radius is too small to complete this arc in one movement, this first step may be divided into two, with the needle first exiting between the incised wound edges and then reloaded and reinserted to exit on the contralateral side.)

- c. The needle body is grasped with surgical forceps in the left hand and pulled upwards with the surgical forceps as the body of the needle is released from the needle driver. Alternatively, the needle may be released from the needle driver and the needle driver itself may be used to grasp the needle from the contralateral side of the wound to complete its rotation through its arc, obviating the need for surgical forceps.
- d. The needle is then reloaded in a backhand fashion and inserted at 90 degrees perpendicular to the epidermis approximately 3 mm from the wound edge on the same side of the incision line as the exit point, between the exit point and the incised wound edge.
- e. The needle is rotated superficially through its arc, exiting on the contralateral side of the wound 3 mm from the incised wound edge.
- f. The suture material is then tied off gently, with care being taken to minimize tension across the epidermis and avoid overly constricting the wound edges.

As with the simple interrupted suture, care should be taken to avoid skimming the needle superficially beneath the epidermis. This may result in wound inversion as the tension vector of the shallow bite pulls the wound edges outwards and down.

Note that the second throw is placed superficial to the first, deeper far–far suture, leading to a nested placement of the suture material. This leads to both wound eversion as well as wound-edge approximation.

The Allgöwer technique involves performing a half-buried vertical mattress suture: the needle is passed from the far entrance point to the interior of the wound. A buried vertical mattress bite is then taken on the contralateral side, and the needle then passes back to the original side, entering near the incised wound edge so that one-half of the wound is closed with a standard vertical mattress suture and the other is closed with a buried vertical mattress.

This technique does not typically permit the same degree of wound-edge apposition as can be accomplished with other transepidermal sutures. In the event that deeper sutures were carefully placed, this may not be a significant drawback, since the wound edges may be well aligned from the placement of these deeper sutures. If not, or if there is a need for improved wound-edge apposition even after placing the vertical mattress suture, additional interrupted sutures may be helpful.

Horizontal mattress

This is a frequently used everting technique used for closure and epidermal approximation. This technique may also be used in the context of atrophic skin, as the broader anchoring bites may help to limit tissue tear-through that may be seen with a simple interrupted suture (Fig. 13-25).

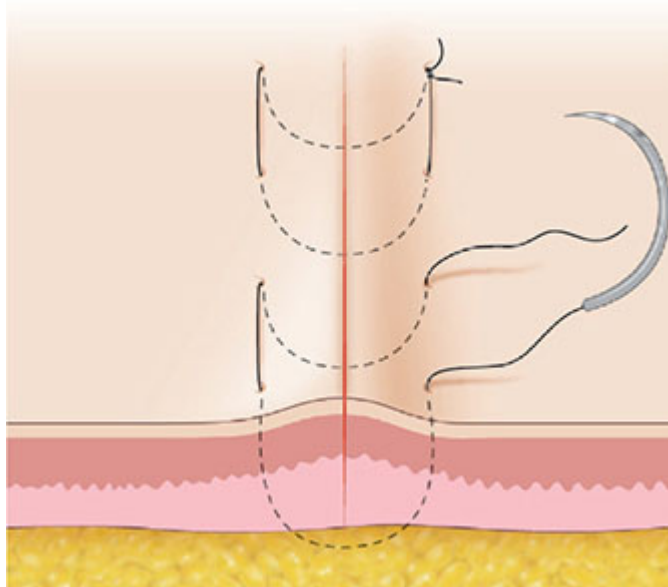


Figure 13-25. Overview of the horizontal mattress suture.

Horizontal Mattress Step-by-Step

- The needle is inserted perpendicular to the epidermis, approximately one-half the radius of the needle distant to the wound edge. This will allow the needle to exit the wound on the contralateral side at an equal distance from the wound edge by simply following the curvature of the needle.
- With a fluid motion of the wrist, the needle is rotated through the dermis, taking the bite wider at the deep margin than at the surface, and the needle tip exits the skin on the contralateral side.
- The needle body is grasped with surgical forceps in the left hand and pulled upwards as the body of the needle is released from the needle driver. Alternatively, the needle may be released from the needle driver

and the needle driver itself may be used to grasp the needle from the contralateral side of the wound to complete its rotation through its arc, obviating the need for surgical forceps.

- d. The needle is then reloaded in a backhand fashion and inserted 90 degrees perpendicular to the epidermis proximal (relative to the surgeon) to its exit point along the length of the wound on the same side of the incision line as the exit point.
- e. The needle is rotated through its arc, exiting on the right side of the wound (relative to the surgeon) in a mirror image of steps b and c.
- f. The suture material is then tied off gently, with care being taken to minimize tension across the epidermis and avoid overly constricting the wound edges.

Since a wide bite of dermis and epidermis is included in the suture arc, it is particularly important to avoid tying the suture material too tight, as this could lead to wound-edge necrosis. Some surgeons utilize bolsters when utilizing this technique under high tension, such as when a 3-0 suture is used on the back, in an attempt to avoid track marks and reduce the risk of tissue necrosis. A wide array of materials may be used for the bolster, including gauze, dental rolls, or plastic tubing. In practice, bolsters are rarely needed with this technique as long as the bulk of the wound tension has been shifted deep using fascial or dermal buried sutures.

Tip stitch

This technique is designed to bring three ends of tissue together, and is often used in the context of a flap, where it permits the tip of tissue to be inset. This approach may be conceptualized as a half-buried horizontal mattress suture ([Fig. 13-26](#)).

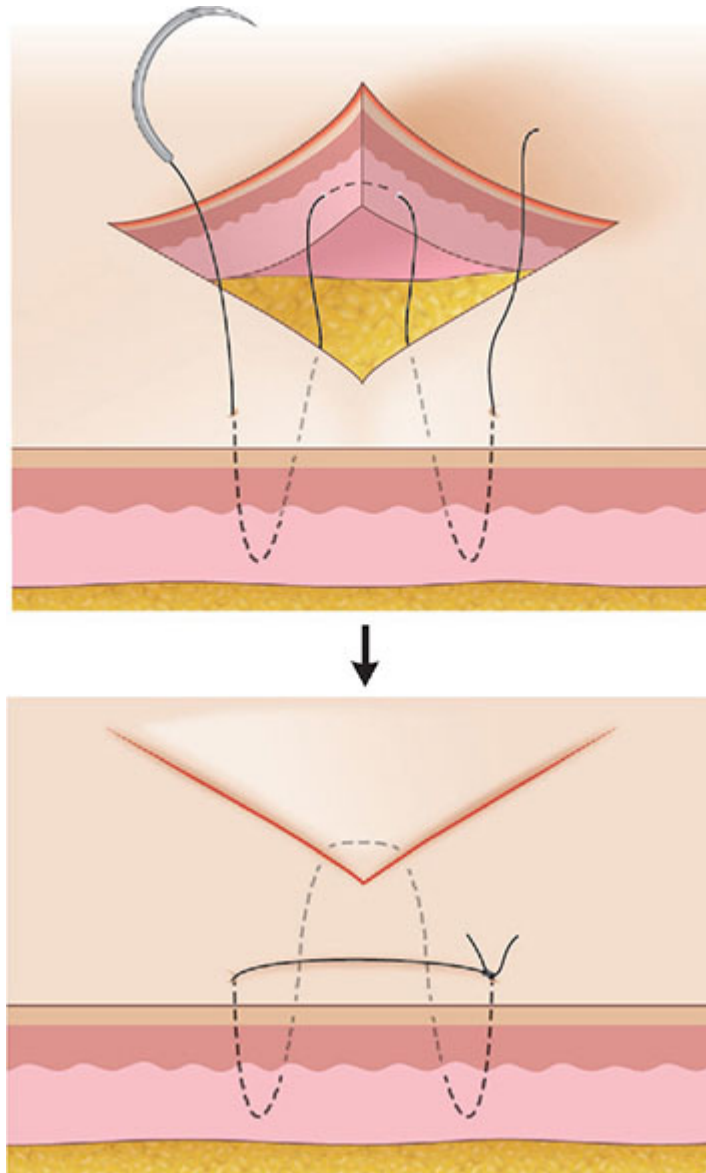


Figure 13-26. Overview of the tip stitch.

Tip Stitch Step-by-Step

- The flap is brought into place using buried sutures, allowing the tip to rest with only minimal tension in its desired position.
- The needle is inserted into the distal edge of the distal nonflap section of skin at 90 degrees with a trajectory running toward the planned entry point in the tip.

- c. The needle is then grasped with the surgical pickups and simultaneously released by the hand holding the needle driver. As the needle is freed from the tissue with the pickups, the needle is grasped again by the needle driver in an appropriate position to place the next throw.
- d. The needle is inserted into the distal portion of the tip at the level of the superficial dermis, which should be the same depth at which it exited in the prior step. Keeping the needle running horizontally, parallel with the skin surface, it is rotated through the dermis of the tip, exiting on the proximal side of the tip at the same depth.
- e. The needle is then reloaded in a backhand fashion and inserted into the dermis of the proximal nontip section of skin, exiting, parallel to its initial entry point.
- f. The suture material is then gently pulled taught and tied utilizing an instrument tie. Care should be taken to minimize tension on this suture to mitigate the risk of flap tip necrosis.

The tip stitch is very useful when bringing the tip of a flap into place, and is used frequently in this situation.^{30–32} Importantly, this technique is designed to gently approximate the tissues so that the flap is properly inset in the surrounding skin. While it bears a technical resemblance to the half-buried horizontal mattress, it is important to appreciate that the tip stitch is *not* designed to work under significant tension, as tension across the suture may lead to necrosis of the delicate and lightly vascularized tip of the flap.

Flap tip necrosis is the greatest risk with this technique, since suture material traverses the dermis containing the tip's vascular supply. This risk may be mitigated by tying the suture relatively loosely so that the tip is not overly constricted when the knot is tied. Additionally, if the bites of dermis are sufficiently set back from the wound edge, a small bite comprising less than half of the dermis in the tip could be taken. This would allow blood supply to the tip even in the context of a relatively tight loop running through the distal flap.

There is sometimes a tendency for the tip to sit deeper than the surrounding tissues. This may be related to the relative upward pull on the nontip sections of skin by the transepidermal sutures.

Finally, while flap tip necrosis is a risk, studies have suggested that the tip stitch provides less vascular constriction than other options, such as placing

two vertically oriented sutures at the edges of the tip or a suture directly through the tip itself.³¹

Purse-string suture

As with its buried variant, this technique is designed to either shrink the size of a defect or obviate it entirely, depending on the degree of tension and the size of the defect (Fig. 13-27).

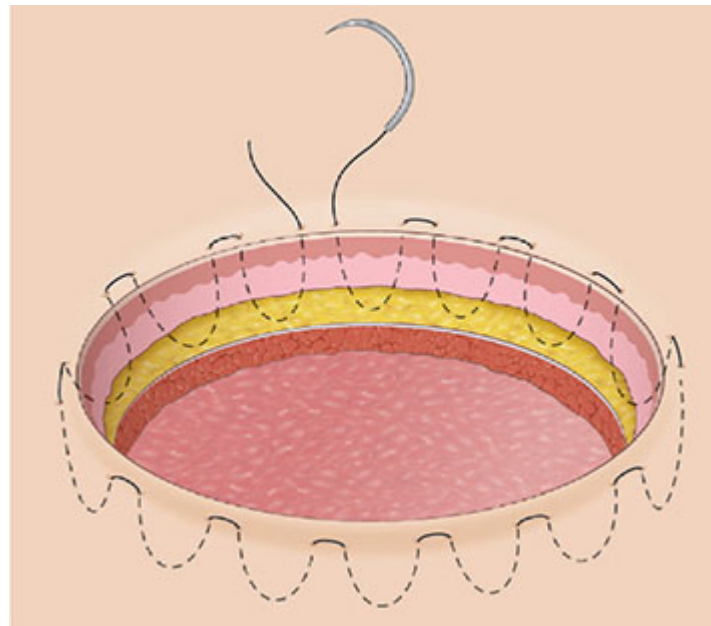


Figure 13-27. Overview of the purse-string suture.

Purse-string Suture Step-by-Step

- a. The wound edges are broadly undermined.
- b. With the tail of the suture material resting between the surgeon and the far end of the wound, the needle is inserted through the epidermis on the far edge of the wound with a trajectory running parallel to the incision. The entry point in the epidermis should be approximately 3 to 6 mm set-back from the epidermal edge, depending on the thickness of the dermis and the anticipated degree of tension across the closure. The needle, and

therefore the suture, should pass through the deep dermis into the undermined space at a uniform depth.

- c. The needle is then grasped with the surgical pickups and simultaneously released by the hand holding the needle driver. As the needle is freed from the tissue with the pickups, the needle is grasped again by the needle driver in an appropriate position to repeat the above step to the left of the previously placed suture.
- d. A small amount of suture material is pulled through and the needle is inserted into the dermis to the left of the previously placed suture, and the same movement is repeated.
- e. The same technique is repeated moving stepwise around the entire wound until the needle exits close to the original entry point at the far end of the wound. Once the point closest to the surgeon is reached, it may be more comfortable to shift to a backhand technique.
- f. Once the desired number of throws has been placed, the suture material is then pulled taught, leading to complete or partial closure of the wound, and tied utilizing an instrument tie. Alternatively, a hand tie may be used if desired.

For a detailed discussion of the advantaged and applications of this technique, see the section above on the buried purse-string technique. A monofilament suture is generally used to permit easy pull-through as well as straightforward suture removal.

The purse-string technique may also be used to affect hemostasis in the case of an oozing wound. For wounds in highly vascular areas, such as the scalp, a purse-string suture may be performed distant from the wound edge; small vessels will be captured within the ring of the purse-string suture and compressed when the suture material is tightened, leading to improved hemostasis. A double ring of purse-string sutures may be used as well to take even better advantage of this hemostatic effect.

VARIATIONS

Running

Running suture techniques are frequently used for their rapidity and ease of placement. The classic technique is the simple running suture (Fig. 13-28), where anchoring sutures are placed at one end of the wound and successive bites are taken moving along the wound. Whether each bite is oriented perpendicularly or diagonally relative to the incision line is largely a point of style.

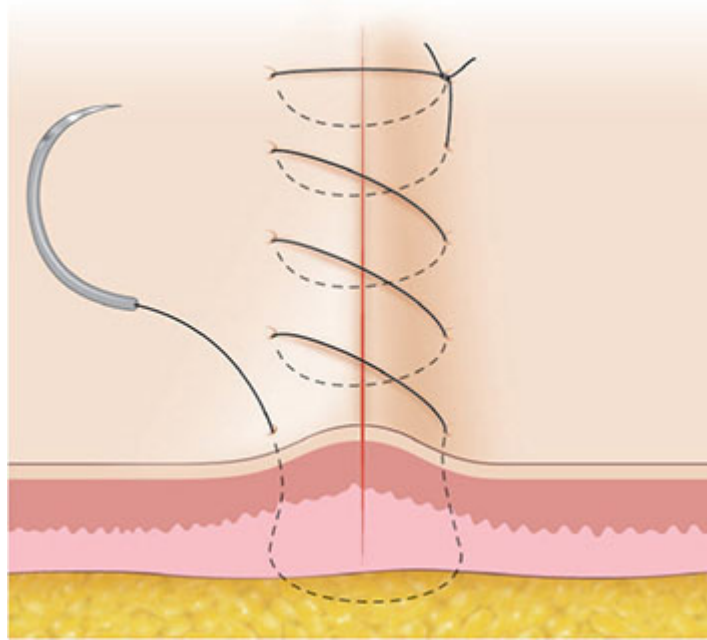


Figure 13-28. The simple running suture technique.

The running horizontal mattress suture, possibly with intermittent single bites, is another useful technique that leads to excellent wound-edge eversion (Fig. 13-29). A running vertical mattress technique is also possible, though it is used less frequently.

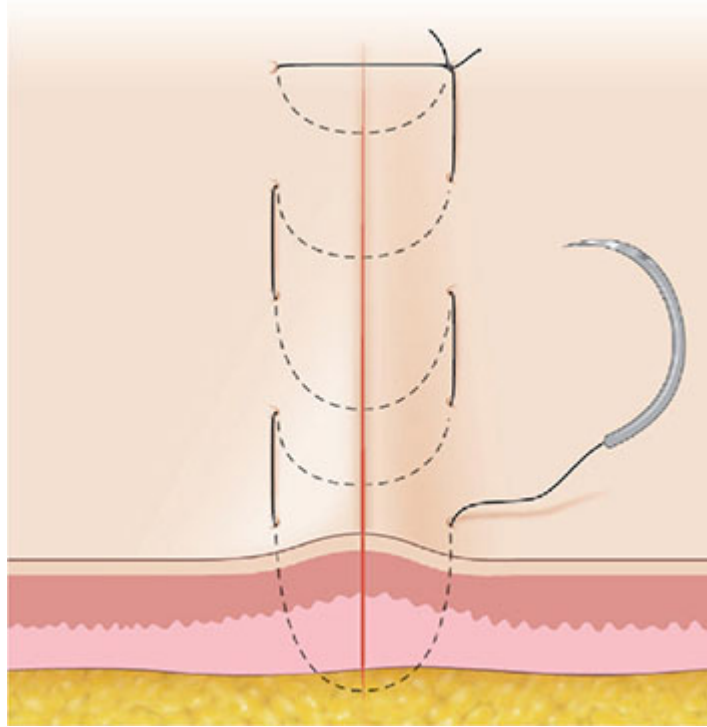


Figure 13-29. The running horizontal mattress technique.

The advantage of running techniques is that they are fairly quick to place, as individual knots are not needed for each suture bite. This is also their central disadvantage, since the entire suture line is secured by only two knots, and if either one is compromised then the integrity of the repair is lost.

Locking

Locking suture techniques, frequently used in concert with running techniques, allow the suture material to be fixed in place. They are frequently used with a simple running suture (the running locking or locked suture), which maintains even tension over each of the suture loop so that bunching and differential tension is less likely. This technique has also been suggested as an adjunct to achieving hemostasis. Other techniques, such as the horizontal mattress suture, may be locked as well, though in practice, this is performed less frequently.

Figure 13-30 shows approaches to hemostasis using a figure-of-eight suture or direct ligature.

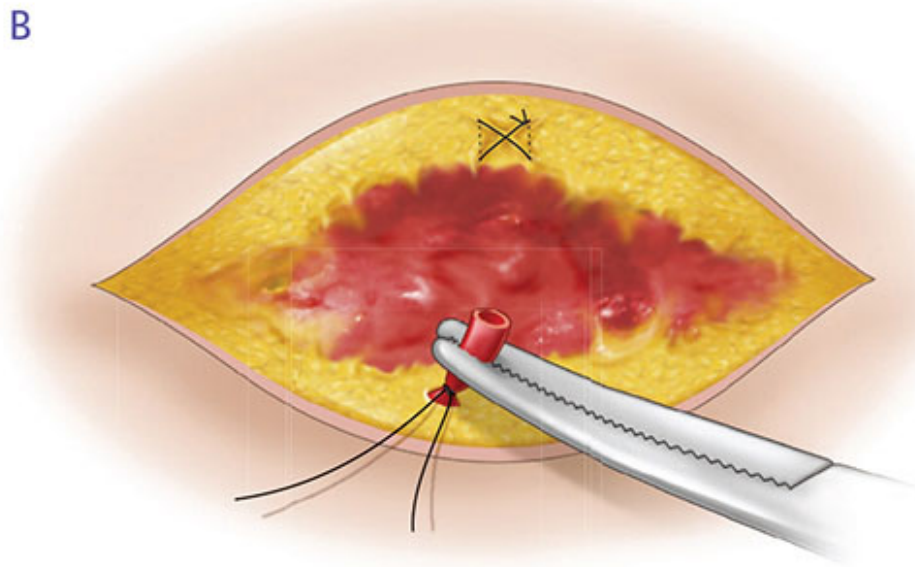
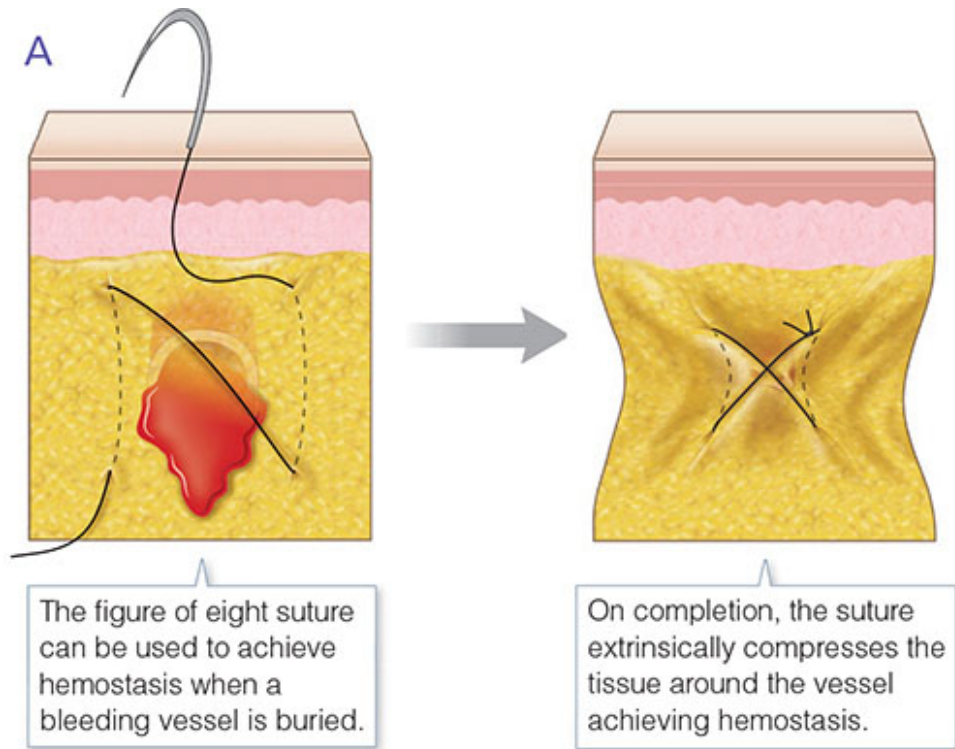


Figure 13-30. Approaches to hemostasis using a figure- of-eight suture or direct ligature.

CONCLUSIONS

Meticulous suturing technique is the cornerstone of every surgical repair. While the dermatologic surgeon does not need to incorporate a vast array of techniques into daily practice, precise placement of sutures coupled with an appreciation of the subtle variations in individual patients that may benefit from particular niche techniques is very helpful and may result in improved surgical outcomes.

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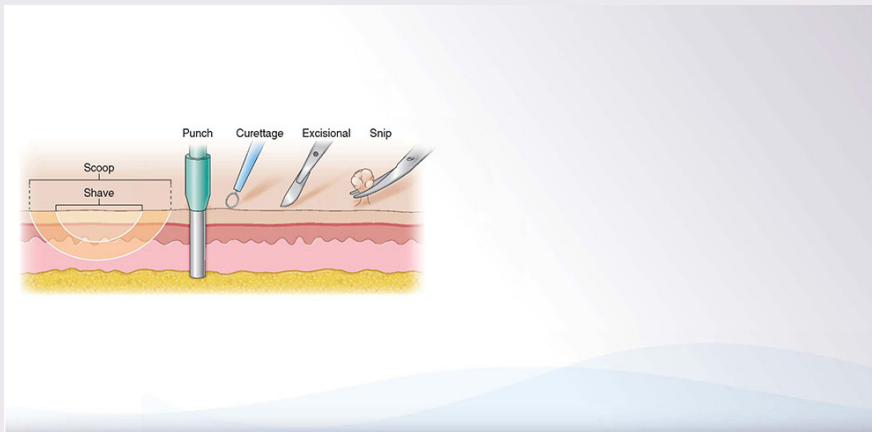
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CHAPTER 14 Superficial Biopsy Techniques

Dirk M. Elston



SUMMARY

- The biopsy of tissue for histological exam remains one of the most informative and cost-effective tests in medical practice, and one of the most common procedures performed by dermatologists.
- In general, all tissues removed during a surgical procedure should be submitted for histopathologic examination.
- Ultimately, the key factor in biopsy success is balancing the need for acquiring an adequate sample for histopathologic evaluation with minimizing the cosmetic and functional sequelae of the biopsy itself on the patient.

Beginner Pearls



- Local anesthesia is a prerequisite for a pain-free biopsy; while patients may rarely request that a biopsy be performed without anesthesia, this should be discouraged, particularly as postbiopsy hemostasis may be more painful than the biopsy itself.
- Patients should receive written instructions regarding wound care.
- Shave biopsies are the cornerstone of dermatologic practice, and are useful in most situations when performed appropriately.

Expert Pearls



- The “excisional biopsy” that is recommended for pigmented lesions suspicious for melanoma includes a deep shave or scoop biopsy.
- Multiple scouting biopsies may be useful when assessing for lentigo maligna.

Don't Forget!



- When sampling for direct immunofluorescence, a punch biopsy from lower extremity skin should generally be avoided both due to a risk of false-negative results and a slower rate of healing.
- For alopecia, punch biopsy for transverse (horizontal) and vertical sections should ideally be performed.

Pitfalls and Cautions



- Often the greatest risk associated with a biopsy is not performing it at all; in the hands of experienced dermatologic surgeons, small biopsies yield nearly undetectable scars, and the diagnostic benefits far outweigh the risks.
- Biopsies from sebaceous skin, such as the nose, may leave pronounced scars that may benefit from later dermabrasion or resurfacing.

Patient Education Points



- Most biopsy sites heal very quickly, but patients should understand that surrounding erythema or excess fibrin formation may be seen, particularly in areas that are subject to friction.
- Preoperative biopsy-site photography may be helpful to reduce the risk of surgical site identification challenges.

Billing Pearls



- Biopsy coding is predicated on the assumption that the purpose of tissue removal is for diagnostic purposes.
- Site-specific biopsy codes should be utilized as appropriate.

CHAPTER 14 Superficial Biopsy Techniques

INTRODUCTION

The biopsy of tissue for histologic examination remains the most informative and cost-effective test in medical practice and one of the most common procedures performed by dermatologists. Usually, a visible lesion is biopsied, but multiple random skin biopsies from the abdomen and thighs may be helpful in the setting of angiotropic lymphoma presenting as fever of unknown origin¹, to obtain tissue for fibroblast culture to assess for a genodermatosis,² or to assess the possibility of immunobullous disease in a patient with generalized pruritus. Reflectance confocal microscopy can be useful to localize the best area to biopsy in a large, poorly defined lesion.³ A range of biopsy techniques are available to the clinician (Fig. 14-1).

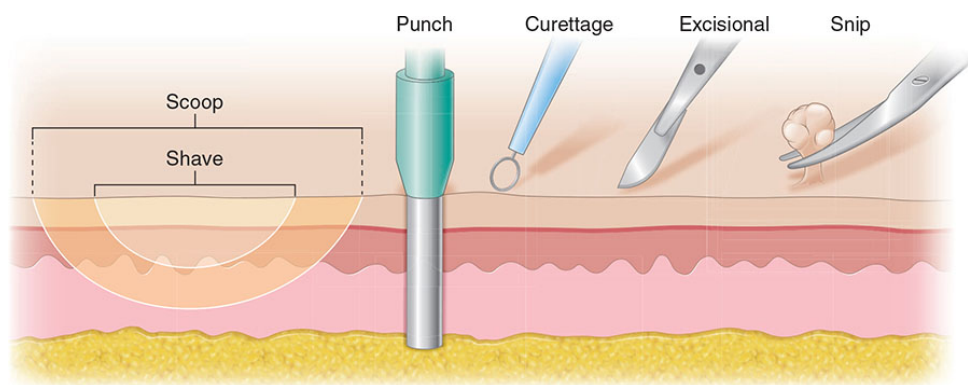


Figure 14-1. A range of biopsy techniques are available.

All tissues removed during a surgical procedure should be submitted for histopathologic examination unless specifically exempted by an

organization's Tissue Committee policy. Such policies typically exempt certain tissues of limited diagnostic value such as femoral head, teeth, nails, and cyst contents. Skin tags are sometimes on the exempt list, but caution is advised, as infundibulocystic basal cell carcinoma, neurofibromas, and fibrofolliculomas may have a tag-like appearance. Any unusual-appearing tag should be submitted for examination, even if Tissue Committee policy exempts them.

Anesthesia, preparation, and postoperative care

Prior to any biopsy, local anesthesia should be obtained by the use of lidocaine. Epinephrine is typically added at a dilution of 1:100,000 or 1:200,000 to induce vasoconstriction, and the lidocaine is frequently buffered with sodium bicarbonate to reduce the burning sensation during injection. Data vary regarding whether warming or chilling the lidocaine solution results in less pain during injection, with some data favoring either method. Slow injection, vibration, application of an ice cube, or pinching of the skin can all be used to decrease the pain involved with injecting the local anesthetic (Table 14-1).

Table 14-1. Techniques to Minimize Biopsy-Site Injection Pain

Slow injection
Vibration
Application of an ice cube
Pinching of adjacent skin

Superficial dermal injection may be more painful, though it provides instant and total anesthesia, while deeper injections hurt less, but take time for complete anesthesia to take effect. Lidocaine is vasodilatory and the vasoconstrictive effects of epinephrine take several minutes to take effect. Thus, biopsy before the onset of action of epinephrine may result in excessive bleeding. Buffered lidocaine has a finite shelf-life (roughly 1 week), and outdated solutions produce only partial anesthesia with excessive bleeding.

Biopsy sites in periorificial areas as well as the lower leg are more prone to infection. For these sites, some clinicians will add 0.15 mL of clindamycin, 150 mg/mL to 50 mL of buffered lidocaine with epinephrine to achieve a concentration of 408 mcg/mL, which has been shown to reduce the rate of local infection.⁴

Correct positioning of the patient is essential. If a biopsy site is likely to bleed, a clean barrier should be placed under the affected area. The area should be clean and well organized with all instruments in place, the biopsy bottle open and labeled with the patient's name, date of birth, and biopsy site, and gauze, hemostatic solution (typically 20% aluminum chloride or Monsel's solution), white petrolatum, and a band-aid already positioned. The surgical assistant should read the site on each bottle before the specimen is placed into the formalin to assure that it is going into the correct bottle. The specimen should be fully immersed in the formalin solution, and visual inspection by the physician should confirm it is in the bottle before the cap is applied.

For biopsies on the head and neck, caustic hemostatic agents should be used with extreme caution near the eyes. A cotton-tipped applicator (CTA) should be dipped into the cautery solution and rolled dry so that drips are unlikely. For lesions near the eyes, the patient should be positioned so that gravity and creases will not draw the hemostatic solution into the eye. The wound should be blotted dry immediately after the biopsy and a CTA moistened with hemostatic solution rolled gently over the site, rather than twisted into the tissue. The wound surface should then be blotted to remove any excess hemostatic solution, as it will otherwise continue to burn the tissue and produce excess scarring.

Monsel's solution has the potential to cause a visible tattoo and must be used in a precise fashion. The wound must be blotted completely dry and the moistened CTA rolled quickly over the surface to obtain hemostasis. Incorrect application of excessive Monsel's solution to a bleeding wound results in a heavy black crust with continued bleeding through the crust, whereas a barely moistened CTA rolled across a dry wound produces instant hemostasis with little risk of tattoo.

Patients should receive written instructions regarding wound care. Most wounds can be cleaned with soap and water, then covered with white petrolatum and a bandage. Antibiotic ointments carry a risk of contact allergy

and anaphylaxis, and make gram-negative wound infection more likely.⁵ An exception is often made for wounds with exposed cartilage, which may be treated with topical gentamycin ophthalmic ointment or 0.025% acetic acid compresses twice daily to reduce the risk of *Pseudomonas* chondritis. Patients should be instructed to expect shave biopsy sites to become red around the edges and slightly yellow in the center during wound healing, and should be reassured that this does not represent infection.

TECHNIQUE

Shave

Biopsies using a shave technique are commonly used to sample neoplastic lesions, but may also be useful in the setting of inflammatory dermatoses if the key histologic features are present in the epidermis and papillary dermis. Engineered sharps (Fig. 14-2) should be considered whenever possible to reduce the risk of injury to members of the care team, though currently available engineered sharps are less rigid than traditional double-edged razor blades and often cannot substitute. Thus most dermatologic surgeons continue to prefer the use of either double- or single-edged razor blades. Others prefer the use of a number 15 or number 10 blade followed by curettage to smooth the wound edges.



Figure 14-2. Shave biopsy technique. The skin is held taut with the nondominant hand, and the fourth finger of the dominant hand may provide additional stabilization.

The technique. The skin is pulled taught in all directions by the surgeon, and an assistant if needed. This allows for more precise sampling of the tissue, a smoother wound edge, and quicker sampling. A shave that won't end, producing a tail, is usually the result of failure to pull the skin taught. The blade is initially angled slightly downward to breach the epidermis, carried horizontally to obtain the specimen, then angled upward to complete the procedure. A fairly rapid but gentle side-to-side motion allows the blade to move smoothly through the tissue without causing ridges. A tumid technique has also been described which involves ballooning of soft papules such as benign nevi and neurofibromas with a mixture of lidocaine diluted with bacteriostatic 0.9% sodium chloride to create a more rigid structure and facilitate shave removal.⁶

Saucerization

When performed properly, saucerization, or scoop shave removal, results in an eponymous saucer-shaped specimen with complete extirpation of the lesion (Fig. 14-3). Saucerization may remain in the dermis or be scooped to subcutaneous tissue.



Figure 14-3. Saucerization biopsy is essentially a deep shave biopsy. This is a preferred technique for suspicious pigmented lesions.

The technique. The overall technique is very similar to a shave biopsy, but the blade is angled more steeply toward the center of the biopsy site, then advanced with a similar rapid but gentle side-to-side motion and a forward scooping motion. Some clinicians prefer to score the skin around the target lesion top aid with an aggressive saucerization. Often, pinpoint-bleeding dermis is visible immediately after a saucerization biopsy (Fig. 14-4).



Figure 14-4. Often, pinpoint-bleeding dermis is visible immediately after a saucerization biopsy.

Punch

The punch technique can be used to sample an inflammatory process, a lesion, or for complete excision of a smaller lesion. Furthermore, lesions slightly larger than 4 mm can often be forced into a 4-mm punch, resulting in satisfactory removal or sampling and a smaller wound.

The technique. When possible, the skin is pulled taught perpendicular to the skin tension lines, so that the wound created by the punch is oval and aligned with the preferred lines of closure. The punch is twisted gently (Fig. 14-5) until the full thickness of the metal portion has entered the skin (Fig. 14-6). The resulting specimen should be removed gently with a needle or by grasping the skin edge with toothed forceps to avoid crushing the specimen (Fig. 14-7). The resulting defect should then be assessed for the ideal closure vector (Fig. 14-8). A suture is placed (Fig. 14-9) and the wound may be closed with either a simple interrupted suture or a cruciate mattress suture (Fig. 14-10). Other novel punch biopsy devices are available as well.⁷

Snip



Figure 14-5. The punch is twisted gently.



Figure 14-6. This continues until the entire device is inserted (when working on the trunk) or once the deep fat has been entered, as seen here.

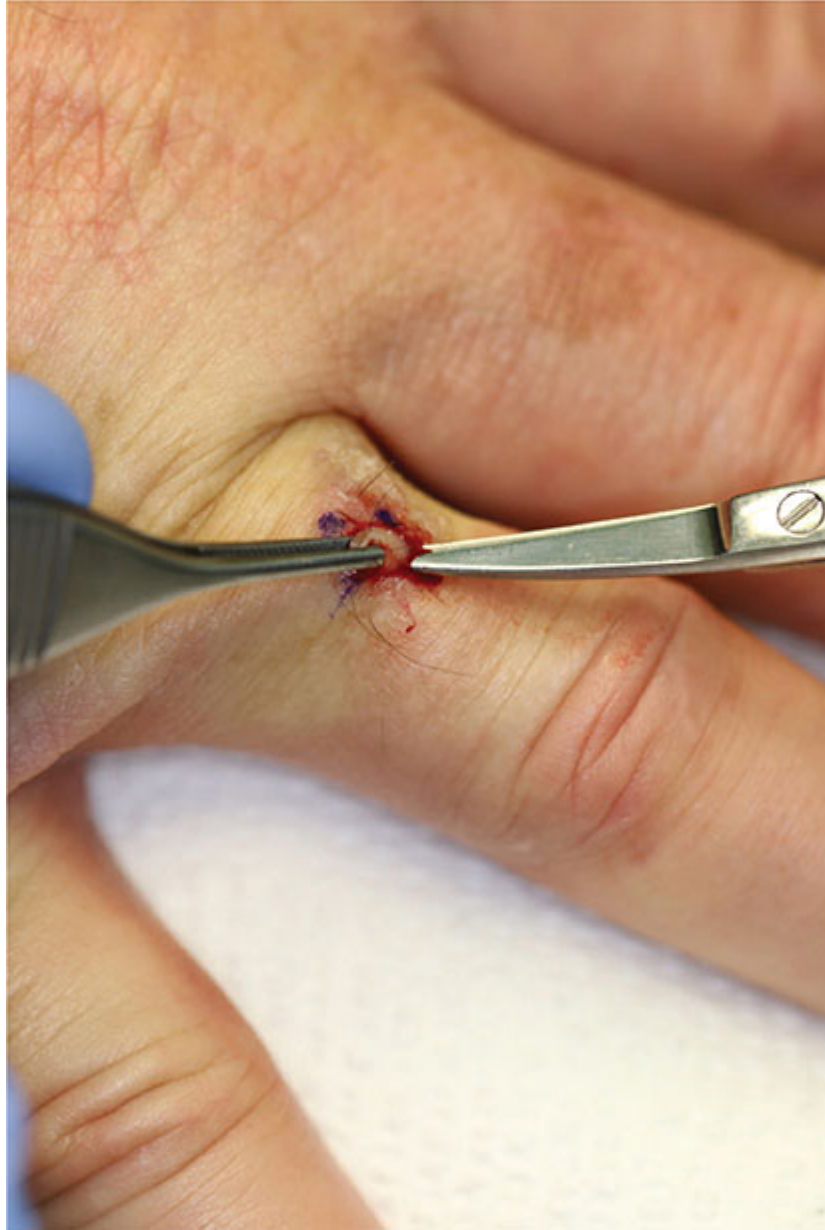


Figure 14-7. The specimen is grasped with forceps, elevated, and the base is snipped if needed at the level of the deep fat.



Figure 14-8. The resulting oval defect should be assessed for the ideal closure vector.



Figure 14-9. A suture is placed.



Figure 14-10. The cruciate mattress suture, essentially two throws of a simple running suture, is useful for punch biopsy closures.

A snip biopsy is performed by utilizing surgical scissors, such as gradle scissors, to remove a pedunculated lesion, generally at its base. After local anesthesia is obtained, care should be taken to avoid elevating the target of

the biopsy with forceps, as a snip biopsy at the base of a manipulated pedunculated papule will result in a depressed postprocedure scar. Instead, the papule should be snipped at its base in the resting position, which should result in minimal postprocedure scarring.

Incisional biopsy

Incisional biopsies allow the surgeon to have full control over the size, shape, and depth of the specimen and are typically followed by straight-line closure. Panniculitis is best diagnosed by an incisional biopsy, although double-punch and other related techniques have also been used.⁸ Large melanocytic lesions are also often approached in this manner.

The technique. A straight line or elliptical incision is made and the desired portion of tissue is removed (Fig. 14-11). The resulting defect is then similar to any other created in excisional surgery (Fig. 14-12), and the wound is closed with simple or layered closure.

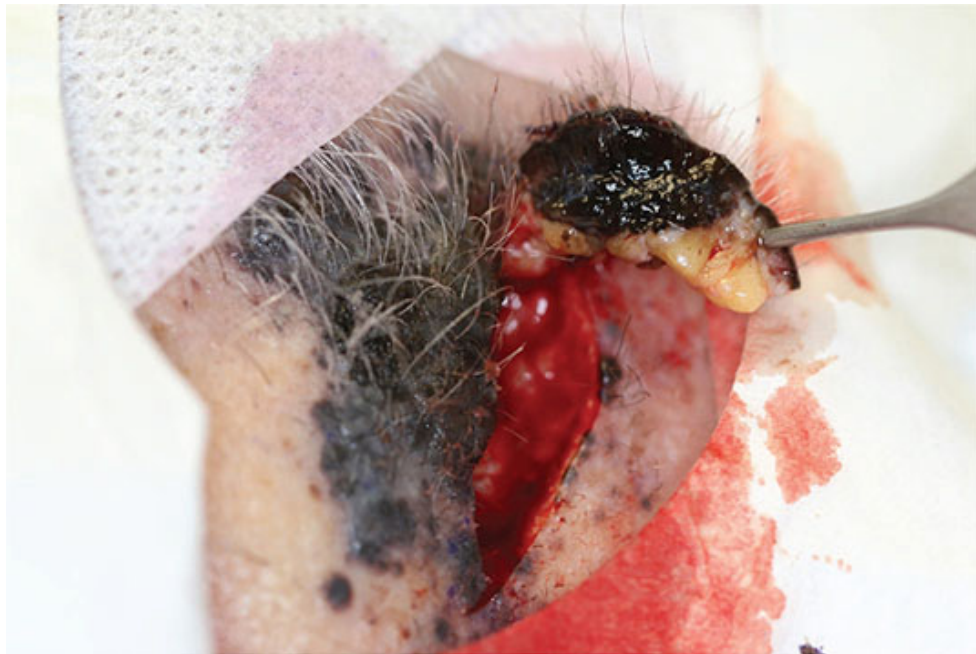


Figure 14-11. An incisional biopsy is useful particularly when a deep melanoma is being sampled to assess the depth of invasion.



Figure 14-12. The resultant defect may then be approached in a similar fashion to any other excisional surgery.

Excision

Excision is the most appropriate technique to produce tissue for examination when the lesion is most likely malignant and subtotal excision may compromise diagnosis or outcome.

The technique. The tissue is removed through the subcutaneous tissue by means of elliptical, circular, or scooped excision. Undermining is often required to free the wound edges to facilitate closure. The wound is closed with simple or layered closure.

Fine-needle aspiration

Fine-needle aspiration (FNA) has been used to sample lymph nodes, soft tissue masses, and even superficial tumors.⁹ The major disadvantage of this technique is that the architecture of the lesion cannot be evaluated. Assessment of architecture is often key to the diagnosis of cutaneous neoplasms as well as inflammatory dermatoses, and FNA is rarely

performed in the dermatologic surgery context unless no other option is available.

Coding for biopsies

The procedure is correctly reported as a biopsy when the clinician's intent is to sample a portion of the lesion for diagnosis, regardless of the technique used. A procedure is correctly coded as a shave when the clinician's intent is complete removal of the lesion, and dermis remains at the base of the wound (Fig. 14-4). A procedure is correctly coded as excision when the clinician's intent is complete removal of the lesion and no dermis remains at the base of the wound. For a full discussion of coding options, see [Chapter 10](#).

SPECIAL SITUATIONS AND SPECIAL SITES

Pigmented lesions

The American Academy of Dermatology (AAD) and the National Comprehensive Cancer Network (NCCN) list narrows excisional biopsy as the preferred technique for sampling lesions suspicious for melanoma. Importantly, saucerization, or a scoop-shave technique, is suitable for thin melanocytic lesions and rarely compromises staging,^{10,11} and indeed, the AAD guidelines themselves include saucerization as a technique to accomplish an excisional biopsy.

In a study of 332 melanoma patients, most diagnostic biopsies had positive margins regardless of biopsy technique, but staging changed in only 8% of patients, of whom 59% had a punch biopsy, 15% an incisional biopsy, 15% a shave biopsy, and 11% an excisional biopsy ($P < 0.0001$). Treatment recommendations changed in 6% of the patients: 2% after excisional biopsy, 5% after shave biopsy, 18% after punch biopsy, and 18% after incisional biopsy ($P < 0.0001$).¹² These data suggest that scoop-shave technique on an appropriately chosen lesion can be a prudent choice, but punch biopsy should be discouraged.

Another study of 709 patients showed that shave biopsies resulted in more positive deep margins ($P < 0.001$). Both shave and punch biopsies resulted in more positive peripheral margins ($P < 0.001$) and a higher risk of finding

residual tumor on wide local excision ($P < 0.001$), but biopsy type did not confer survival advantage or impact tumor recurrence, suggesting that experienced clinicians should be free to choose the most appropriate technique for a given lesion.¹³ Other authors have published data supporting similar conclusions.^{14,15}

In the setting of lentigo maligna, it is often impractical to remove the entire lesion, and sampling of the lesion may be more appropriate. A broad area of the dermal–epidermal junction may be demonstrated by a broad, thin biopsy resembling properly cut prosciutto. If the lesion is mottled with many colors, multiple small thin shaves sampling each color may be more appropriate. If a skin crease naturally traverses the area to be sampled, an incisional biopsy can be aligned along the crease.

Immunobullous disease

In the setting of suspected immunobullous disease, biopsies for direct immunofluorescence should be taken from nonbullous lesional skin or perilesional skin within about 1 cm of a bulla. Nonbullous lesional skin has the higher yield.¹⁶ Lower extremity skin should be avoided because of a greater risk of false-negative results.^{17,18} Specimens for light microscopy should demonstrate an intact vesicle or bulla whenever possible. For larger lesions, the specimen should contain both portions of the blister and intact skin so that the edge of the blister and a portion of the bulla. A punch biopsy or shave excision works well for small vesicles, while a scooped shave may be useful to harvest larger bullae intact.

Tissue obtained for direct immunofluorescence should be placed in Michel's medium or Zeus medium.^{19,20} Some immunodermatology laboratories prefer specimens transported in saline to reduce background staining. Saline-preserved specimens should be processed within 24 hours. If the specimen is inadvertently placed into formalin, it should immediately be removed and rinsed in normal saline. Brief formalin immersion produces false-negative results for pemphigus, but not for diseases characterized by deposits at the dermal–epidermal junction.²¹ In the setting of tense blisters suggesting a subepidermal bullous disease, a single punch technique has been used to obtain both H&E and DIF specimens and provide salt-split, skin like diagnostic information.²²

Connective tissue disease

In contrast to immunobullous disease, biopsies of suspected connective tissue disease for DIF are best demonstrated in well-established lesion >6 months old. In the setting of systemic LE, the lupus band test performed on normal sun-protected skin has largely been replaced by assays for double-stranded DNA antibodies which identify the same population at risk for renal disease.

Vasculitis

In the case of suspected vasculitis, biopsies for H&E should be taken from a well-established purpuric lesion (at least 72 hours old), while biopsies for DIF should be taken from an acute lesion (<24 hours old). IgA vasculitis is more likely to retain positive DIF findings in established lesions, when compared with other forms of vasculitis.

Alopecia

To maximize the diagnostic yield in the setting of alopecia, a 4-mm punch biopsy specimen should be obtained from a well-developed lesion, preferably of several months' duration, but still active. Many labs prefer transverse sections, although serial vertical sections are superior in the setting of scarring alopecia. A separate biopsy can be bisected vertically to produce a half punch suitable for DIF and another half punch added to the formalin bottle to provide vertical sections. When biopsies of active lesions prove to be nondiagnostic, a biopsy from a scarred area evaluated with elastic tissue stains or polarized microscopy can provide additional information.^{23–26} Both trichoscopy and confocal microscopy can be useful in site selection, directing the clinician to established areas of active inflammation.^{27–29} The punch should always enter the scalp at the same angle as the emerging hairs to avoid transecting hair follicles. Hemostasis is more easily obtained with gel foam than with sutures.

Mucosal and genital biopsies

The thin skin of the lips has a tendency to retract when a shave biopsy is performed. Therefore, utilizing a tumid-type technique, raising a significant wheal in the target tissue, may serve to develop a more rigid substrate for shave biopsy. Alternatively, a chalazion clamp may be used, a snip biopsy may be performed after grasping the target tissue with dressing forceps, or a punch biopsy may be performed in lieu of a shave approach. Similar approaches may be used when performing biopsies on the vulva or shaft of the penis.

CONCLUSIONS

Careful attention to biopsy technique, patient positioning, site selection, and hemostasis will result in better outcomes for the patient and a more efficient practice for the clinician. Ultimately, the key factor in biopsy success is balancing the need for acquiring an adequate sample for histopathologic evaluation with minimizing the cosmetic and functional sequelae of the biopsy itself on the patient.

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CHAPTER 15 Cryosurgery

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SUMMARY

- Cryosurgery is a versatile technique and a mainstay of the dermatologic surgeon's therapeutic armamentarium.
- While used largely for actinic keratoses, cryotherapy may be used for an array of dermatologic conditions.
- Cryosurgery has become a well-established, safe treatment modality for a wide range of conditions, and will likely remain a fixture in dermatologic surgery for years to come.

Beginner Pearls



- It is always better to undertreat than overtreat an area. Warn patients that the areas being treated may not resolve and that additional treatments may be needed.
- Localize tissue treatment to the area of concern; it is best to avoid overly broad treatment that only serves to cause more tissue damage.

Expert Pearls



- Intralesional cryoneedles and other similar approaches may be used to treat larger or more aggressive tumors.
- In such cases, accurately gauging the temperature at the deepest section of the target lesion may be helpful.

Don't Forget!



- Melanocytes are highly cold-sensitive, while malignant cells are most resistant to cold-induced damage. Therefore, pigmentation changes are seen frequently with even moderately aggressive cryosurgery.
- Cryosurgery induces tissue necrosis through several pathways, including direct cellular injury, intra- and extracellular ice deposition, and damage to the microcirculatory vasculature.

Pitfalls and Cautions



- Healing time after cryosurgery varies, and patients will almost always have significant edema and erythema in the immediate postprocedure period.
- On the scalp and legs, sites may take significantly longer to heal adequately.

Patient Education Points



- When treating actinic keratoses, there is often a field of actinic damage where incipient actinic keratoses are forming. Additional actinic keratoses in this area may be a result of this actinic field injury rather than a recurrence due to inadequate cryosurgery.
- Patients should be told what to expect in the posttreatment period to minimize anxiety.

Billing Pearls



- Cryosurgery coding depends on the lesion and anatomic site being treated. For actinic keratoses, use code 17000 for the first lesion and 17003 for each additional (up to 14), and code 17004 if 15 or more are treated. For warts and other benign lesions, use code 17110 (a single code for up to 14 lesions) or 17111 (15 or more). For genital lesions, use code 54056 for the penis or 56501 for the vulva. For malignant destruction, use the 172XX series.

CHAPTER 15 Cryosurgery

INTRODUCTION

Cryotherapy, the application of cold temperatures for therapeutic purposes, has been utilized for thousands of years. Historical records dating as far back as 2500 BC reveal that the Egyptians used cold to treat injuries and infected wounds.¹ In the 5th century BC, Hippocrates documented the analgesic and anti-inflammatory properties of this modality.² However, the technique of cryosurgery, which specifically denotes the use of extreme cold for cellular destruction, has its origin in more modern times. Around the turn of the 20th century, Dr. Campbell White, a dermatologist in New York, first pioneered the use of liquefied air for the treatment of warts, nevi, and malignancies. In subsequent years, cryogen delivery was enhanced with the development of handheld spray units and the availability of liquid nitrogen. Currently, cryosurgery exists as an extremely versatile treatment modality that is indicated for the treatment of numerous benign, premalignant, and malignant lesions.

CRYOGENS

Presently, liquid nitrogen is used exclusively in the vast majority of dermatology settings. However, prior to its development, several other cryogenic substances were employed for similar purposes. The original cryogen was liquefied air (-190°C), which was composed of approximately 78% nitrogen, 21% oxygen, 1% argon, with traces of other gases.^{2,3} While effective, liquid air was difficult to obtain, and was subsequently superseded by solidified carbon dioxide (-78.5°C) in the early 1900s.⁴ In the 1920s, liquid oxygen (-182.9°C) became readily available, but its use was limited

by safety concerns including flammability.⁵ The use of liquid nitrogen (-195.6°C), which remains the most frequently employed cryogen, was first reported in 1950.³ In contrast to liquid oxygen, liquid nitrogen is inert, and is considered to be both safe and effective.

INSTRUMENTS

There are a variety of methods that may be used to apply liquid nitrogen. The most common of these in dermatologic settings is the use of a handheld spray unit (Fig. 15-1). These units are available in multiple sizes and with several modifications that allow cryogen delivery to be tailored according to circumstance. Techniques of spray delivery include direct application to the center of a lesion, a spiral pattern that begins in the center and radiates outward, and a “paintbrush” pattern in which the nozzle is moved back and forth from one side to another. Various tips are available for these units (Fig. 15-2). Devices such as an insulated plastic cone may be used in conjunction with the spray method to increase the concentration of liquid nitrogen applied to a particular location. The cone is placed directly onto the skin, and enhances both the rate and depth of freezing.



Figure 15-1. The liquid nitrogen spray unit.



Figure 15-2. Various tips are available for the units.

To increase both the depth and lateral extent of freezing, cryoprobes may be used. Cryoprobes are tips cooled by circulating cryogen that can be inserted directly into the skin. They are available in a variety of shapes and sizes, and are particularly useful for treating sebaceous hyperplasia and small vascular lesions. Additionally, cryoprobes are well suited to treat small tumors on the eyelid or lip where fine-tuned control of cryogen delivery is essential.⁶

A variation of the probe technique, the intralesional cryoneedle, may be useful for solid masses. This device can be passed through a tumor until the tip reemerges on the opposite side. Liquid nitrogen is circulated through the lumen of the needle, forming an ice cylinder in the surrounding tissue that expands circumferentially. The advantage of this technique is that colder temperatures may be applied directly to deeper structures, rather than the skin surface.⁷ This method may be especially useful for the treatment of hypertrophic scars and keloids.⁸

The dipstick method, in which a cryogen-soaked cotton swab is applied directly to the skin, may also be useful. This technique is most suitable for the treatment of benign, superficial lesions, as the maximum depth of freezing achieved is 2 to 3 mm.

TECHNIQUES

While there are no absolute contraindications to cryosurgery, some comorbidities are more likely to be associated with adverse outcomes. Some of these include known cold intolerance, cold urticaria, cryofibrinogenemia, cryoglobulinemia, and Raynaud's phenomenon. Collagen vascular disease, multiple myeloma, hemodialysis, thrombocytopenia, agammaglobulinemia, and blood dyscrasias of unknown origin have also been noted as relative contraindications.⁹

Several factors affect the amount of tissue destruction achieved with cryosurgery. When tissue is frozen, an ice ball forms that serves as a visible indication of the extent of surface freezing (Fig. 15-3). However, the depth of freezing, also referred to as the depth dose, may be more difficult to determine. The ice ball maintains a hemispherical shape until it reaches a

depth of 5 to 7 mm, at which point it will begin to plateau. For lesions exceeding this depth, a thermocouple may be useful. This device should be inserted into the skin at a 25- to 30-degree angle until the tip reaches the base of the lesion, and will provide a more accurate determination of tissue temperature, though these are rarely used in clinical practice.



Figure 15-3. When tissue is frozen, an ice ball forms that serves as a visible indication of the extent of surface freezing.

The temperature achieved with cryosurgery is directly related to the degree of resultant cellular injury. Melanocytes are most sensitive to cold, and are irreversibly damaged at temperatures ranging from -4° to -7°C . Keratinocytes are destroyed at temperatures ranging from -20° to -30°C , and death of fibroblasts occurs between -30° and -35°C . Malignant cells are most resistant to cold-induced damage, requiring temperatures below -40°C for destruction.¹⁰ Therefore, when treating a malignancy, a temperature endpoint between -50° and -60°C is advisable (Fig. 15-4).

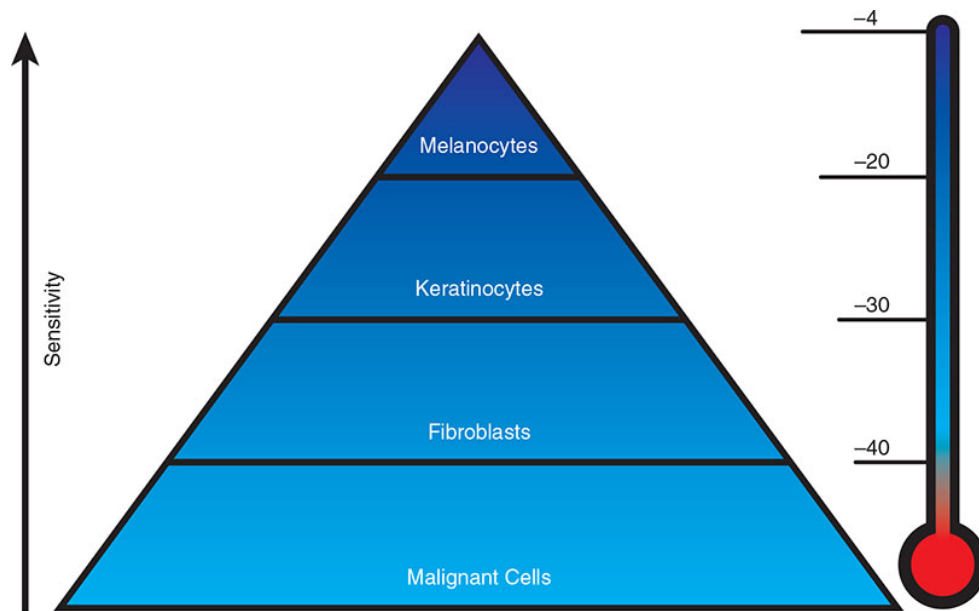


Figure 15-4. There is marked variability in the cold sensitivity of different cell types.

The freeze time, or duration of cooling, is another important consideration. In general, benign lesions require shorter freeze times, and may be sufficiently treated with a single freeze–thaw cycle. Malignancies often require a double freeze–thaw cycle, and freeze times exceeding 45 seconds.

Additionally, the lateral spread of freeze, or margin of freeze, varies depending on the type of lesion. For benign lesions, margins of 2 to 3 mm are sufficient, whereas malignant lesions may require margins of 5 mm or more.

Certain adverse responses, such as pain and blistering, should be anticipated following cryotherapy; when these become intolerable or progress to longer-term effects, they may be considered complications.

In the absence of local anesthetic or pre-existing neuropathy, all patients will feel pain during the treatment. Many patients will describe burning or stinging pain initially that may progress to a dull throbbing pain. The pain usually resolves spontaneously within minutes. Treatments to certain parts of the body, such as the ear, finger tips, lips, temples, and scalp may cause more severe pain. Additionally, cryosurgery to the scalp, temple, or forehead may occasionally be associated with migraine-like headaches.⁹

Almost all treated patients will also develop localized edema, blister formation, and erythema (Fig. 15-5). The amount of edema is related to both the intensity of the treatment and the lesion location. The eyelids, labia minora, lips, and foreskin have more lax skin and therefore develop greater edema.⁹



Figure 15-5. Almost all treated patients will also develop localized edema, blister formation, and erythema. Note the immediate postprocedure erythema.

Hypopigmentation is perhaps the most common complication. One prospective study of 421 actinic keratoses treated with cryosurgery reported hypopigmentation in 29%. The incidence of hypopigmentation increased with the duration of freezing time.¹¹ This may stem mechanistically from the fact that melanocytes are more cold-sensitive than keratinocytes and fibroblasts.

Hypopigmentation is especially common in those with darker skin types. Paradoxically, hyperpigmentation may also develop following cryosurgery-induced inflammation.

Sensory and motor neuropathy may also develop following cryosurgery. The extent of neuropathy will depend on the cryosurgery dose and lesion location. One study of sensory neuropathy associated with cryotherapy revealed complete recovery in all subjects by 18 months.¹² Infection, atrophy, hemorrhage, milia, hypertrophic scarring, bone necrosis, ectropion, and alopecia are additional reported complications.⁹

MECHANISM OF ACTION

Cryoablation induces tissue necrosis through multiple mechanisms including direct cellular injury, apoptosis, vessel thrombosis, and immune response activation. Direct cellular injury occurs through the formation of intracellular and extracellular ice (Fig. 15-6). Intracellular ice results in the destruction of cell membranes and vital organelles, and is maximized by rapid freezing. Extracellular ice alters the osmotic gradient between cytoplasm and extracellular fluid. Together, these changes result in irreversible cell death. Cellular damage continues during the thawing phase, in which the formation of large ice crystals imposes shearing forces on surrounding tissue. To maximize the damage accrued during recrystallization, thawing should proceed as slowly as possible.¹³

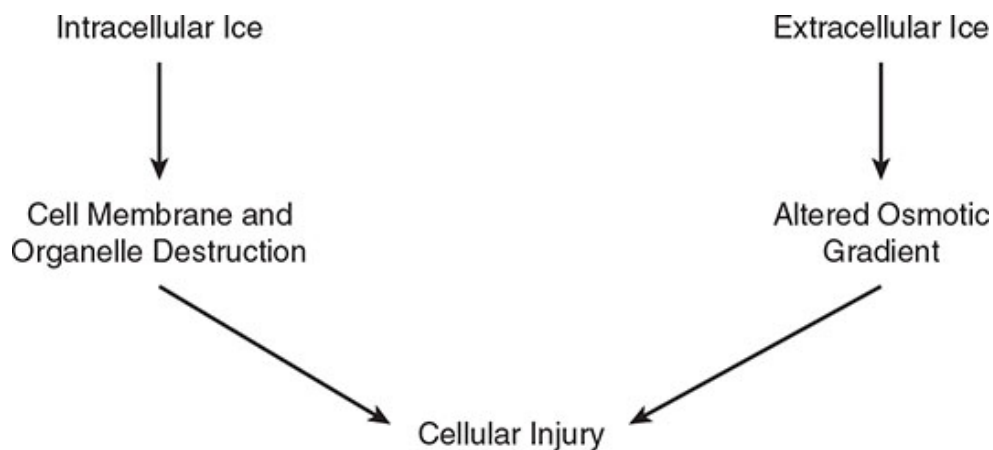


Figure 15-6. Direct cellular injury occurs through the formation of intracellular and extracellular ice.

In addition to direct cellular injury, cryosurgery also has a destructive effect on microcirculatory vasculature. Freezing causes damage to capillary endothelial cells, resulting in platelet aggregation and thrombosis of papillary dermal vessels. Additionally, freezing destroys mast cell membranes and causes degranulation, which results in histamine-mediated increases in capillary permeability. Subsequent vasodilation results in increased edema and inflammatory cell infiltration.

The immunologic effect of cryosurgery is less well defined. Evidence of a systemic immune reaction is found in reports citing resolution of multiple verrucae after cryosurgical treatment of only a few lesions—an abscopal response. This reaction is likely incited by the release of DNA, RNA, uric acid, and other intracellular elements following the destruction of cell membranes. These elements activate toll-like receptors, triggering subsequent immunologic cascades. An innate immune response is generated initially, resulting in early infiltration of granulocytes, monocytes, and macrophages. An adaptive immune response follows, in which dendritic cells travel to regional lymph nodes to undergo maturation and antigen presentation.¹⁰

INDICATIONS

Cryotherapy has been reported for a broad range of dermatologic conditions including malignant, infectious, autoimmune, and inflammatory conditions.¹⁴ General guidelines recommend a single freeze–thaw cycle for treating benign conditions. This approach is less likely to lead to poor healing or scarring, and treatment can be safely repeated at a later date since the condition is benign. The majority of published findings for treating many of the listed conditions consist of case reports or small uncontrolled series, though larger studies exist for the treatment of basal cell carcinoma, squamous cell carcinoma, and actinic keratoses have been performed. [Table 15-1](#) is a summary of benign conditions treated with cryotherapy and [Table 15-2](#) is a summary of malignant and premalignant conditions treated with cryotherapy.

Table 15-1. Benign Conditions Treated with Cryotherapy

Acne	Granuloma annulare	Porokeratosis plantaris discreta
Acne keloidalis	Granuloma faciale	Porokeratosis of Mibelli
Adenoma sebaceum	Granuloma pyogenicum	Prurigo nodularis
Alopecia areata	Hemangioma	Pruritus ani
Angiokeratomas	Herpes labialis	Psoriasis
Angiokeratoma of Fordyce	Idiopathic guttate hypomelanosis	Rhinophyma
Atypical fibroxanthoma	Kyrle's disease	Rosacea
Cherry angiomas	Leishmaniasis	Sarcoid
Chondrodermatitis nodularis helices	Lentigines	Sebaceous hyperplasia
Chromoblastomycosis	Lentigo simplex	Seborrheic keratosis
Clear cell acanthoma	Lichen sclerosus et atrophicus	Solar lentigo
Condyloma acuminatum	Lupus erythematosus	Syringoma
Dermatofibroma	Lymphangioma	Trichiasis
Disseminated superficial actinic porokeratosis	Lymphocytoma cutis	Trichoepithelioma
Elastosis perforans serpiginosa	Molluscum contagiosum	Varicose veins
Epidermal nevus	Mucocele	Venous lake
Erosive adenomatosis of the nipple	Myxoid cyst	Verrucae
Folliculitis keloidalis	Orf	Xanthoma

Table 15-2. Malignant and Premalignant Conditions Treated with Cryotherapy

Actinic cheilitis
Actinic keratosis
Bowen's disease
Erythroplasia of Queyrat
Keratoacanthoma
Lentigo maligna
Squamous cell carcinoma in situ
Basal cell carcinoma
Squamous cell carcinoma

Warts

Verrucae vulgaris are commonly treated with cryosurgery. A 2014 Cochrane review analyzed 21 studies of cryosurgery for treating warts.¹⁵ Meta-analysis of cryosurgery versus placebo failed to show a statistically significant difference; 41 of 107 (38.3%) of warts resolved with cryosurgery. The largest and the most recent of the included studies comparing cryosurgery to placebo did, however, demonstrate a therapeutic advantage to cryosurgery. Thirty of 76 (39.5%) warts in the cryosurgery group responded compared to 13 of 82 (15.9%) in the placebo group.¹⁶ Furthermore, treatment intervals

every 2, 3, or 4 weeks did not impact cure rates. Aggressive cryotherapy was, however, more effective than gentle cryotherapy. Aggressive cryotherapy was also associated with a higher incidence of pain and blistering.¹⁷

Seborrheic keratoses

Cryosurgery is a well-described therapy for seborrheic keratoses. It is critical, however, that the clinical, or preferably histological, diagnosis is confirmed prior to treating with cryotherapy. One study comparing curettage to cryotherapy revealed that 15 of 25 subjects (60%) preferred cryotherapy, while 9 of 25 (36%) preferred curettage. Even though cryotherapy was associated with increased pain, subjects preferred this modality largely due to the decreased requirement for postoperative wound care. Self-reported cosmesis was reported to be the same between the two groups. Physician evaluation showed that there were more redness and tendency for hypopigmentation in the curettage group, and more frequent residual seborrheic keratoses in the cryotherapy group.¹⁸

More recently, a randomized prospective trial of 120 seborrheic keratoses compared cryosurgery to an erbium: YAG laser for treating seborrheic keratoses. Following the first treatment session, 100% of the Er:YAG-treated lesions resolved, while only 63.8% of those treated by cryosurgery completely responded. Both groups received topical anesthesia with EMLA cream prior to treatment, and neither group reported severe pain or interrupted therapy due to pain.¹⁹

Granuloma annulare

Granuloma annulare is another benign condition effectively treated with cryosurgery. A single freeze–thaw treatment cycle lasting 10 to 60 seconds using either liquid nitrogen or nitrous oxide leads to lesion resolution in 25 of 31 (80.6%) of patients. All patients developed blisters within 24 to 48 hours of treatment. Cryoatrophy (14.3%) and dyspigmentation (7.1%) were the most commonly reported adverse effects. Significantly, cryoatrophy developed in 21% of subjects treated with liquid nitrogen and none of the subjects who received nitrous oxide.²⁰

Actinic keratoses

Actinic keratoses are a well-described and widely practiced indication for cryotherapy. Lesions may be treated with a cryospray or by using a cotton-tipped applicator, though the latter is now used infrequently. One study from 1982 reported a 98.8% cure rate in the treatment of 1018 actinic keratoses in 70 patients. At follow-up ranging from 1 to 8.5 years after the treatment, 12 recurrences were noted.²¹ Cryosurgery is often the treatment of choice for discrete lesions given its quick treatment time, wide availability, and minimal expense. A more recent Cochrane Database review from 2012 evaluated various available fields and individual lesion therapies for actinic keratoses. Photodynamic therapy, compared to cryotherapy, was more effective and yielded an improved cosmetic outcome for treating individual actinic keratoses.²² This finding should, however, be weighed against the convenience and cost-effectiveness of cryotherapy.

Basal cell carcinoma

Much of the primary literature utilizing cryotherapy to treat basal cell carcinoma is over 30 years old. One study of 628 basal cell carcinomas treated between 1980 and 1984 reported a 5-year cure rate of 99%.²³ The authors note that most of the cancers were “small (<0.5 cm) to medium (0.5–2.0 cm)” or superficial. Additionally, lesions located in critical anatomic locations—such as medial canthus—were excluded. The treatment technique sometimes included preoperative treatment with a local anesthetic and curettage. Depending on the size and thickness of the tumors, freeze time varied from 40 to 90 seconds, and the authors preferred to include repeated freeze–thaw cycles.

A 2003 review of uncontrolled prospective studies of basal cell carcinomas treated with cryosurgery reported recurrence rates ranging from 0% to 21% for follow-up at 6 months to 10 years.²⁴ If the single study of 19 patients with eyelid tumors is excluded, the highest reported recurrence rate is 8.2%. Cosmesis was quantitatively evaluated in only two studies, but was generally commented on as “acceptable” to “excellent.” All studies were assigned a C grade, per Sackett’s rules of evidence, indicating lack of

randomization, placebo control, or blinding, and were case reports and case series.²⁵

In addition to problems with study design noted above, at least one author has challenged the previously reported high cure rates for two other reasons.²⁶ First, previous studies were not stratified based on histological subtype. In addition, the treatment techniques reported in the initial publications likely differ significantly from how cryotherapy is currently used. Most contemporary dermatologists are unlikely to debulk a tumor with curettage or electrosurgery prior to cryotherapy. Furthermore, contemporary dermatologists probably do not utilize freeze cycles as long as those previously reported. Accordingly, the cure rates from older studies may not be replicated in contemporary practices.

Squamous cell carcinoma

Data on cryotherapy for squamous cell carcinomas is similar to that found for the treatment of basal cell carcinomas in many respects. Pooled analysis of observational studies using cryotherapy reported only one recurrence (0.8%) out of 273 patients treated in 8 studies.²⁷ Mean follow-up ranged from 2 to 5 years. A retrospective series of 563 squamous cell carcinomas treated over a 23-year period described a 97% cure rate, though the definition of “cure” was unclear and no follow-up time was reported.²⁸ Of all the modalities included in the pooled analysis of observation studies for interventions for nonmetastatic cutaneous squamous cell carcinoma, cryotherapy along with electrodesiccation and curettage had the highest cure rates for squamous cell carcinomas, but most tumors were small and deemed to be low risk.²⁷ As with the studies on basal cell carcinoma, it’s not clear that the techniques employed for the studies—including debulking and prolonged freezing times—are the same techniques employed by contemporary dermatologists.

Lentigo maligna

Cryotherapy has also been described for the treatment of lentigo maligna. While clearly excision is preferable, the size, location, and comorbidities sometimes make excisional surgery impractical. At least three small case series describe cryosurgical treatment of lentigo maligna. One series of 30

patients with lesions measuring 1.3 to 4.5 cm treated between 1977 and 1992 reported two recurrences (6.6%).²⁹ This study utilized a double freeze–thaw cycle with 1-cm lateral spread. A study of 20 patients reported 2 recurrences (10%)³⁰, while another study of 20 patients reported 3 recurrences (15%).³¹ Contemporary dermatologists may treat lentigo maligna with cryotherapy less frequently due to both advances in reconstructive techniques as well as concerns with sampling error. Without the opportunity for histological evaluation, the presence of microscopic foci of lentigo maligna melanoma (which may occur in a significant proportion of cases) cannot be identified, and prognostic outcome cannot be predicted accordingly.

Kaposi sarcoma

Kaposi sarcoma, when limited to the skin, may respond well to cryosurgery. A retrospective cohort study of 30 patients was reported in 2013. Patients received two freeze–thaw cycles lasting 15 to 40 seconds/cycle with a 3-mm margin every 4 weeks. Nineteen (63%) patients experienced a complete response, eight showed a partial response, and three patients discontinued therapy due to an increasing number of lesions.³²

CONCLUSIONS

Cryosurgery has become a well-established, safe treatment modality for a wide range of conditions, and will likely remain a fixture in dermatologic surgery for years to come. New developments may include modifications in cryogen delivery methods and the refinement of temperature detection at the surface of the skin. Additionally, other techniques, including fractional cryosurgery, may become more widely employed, expanding the application of cryosurgery to larger tumors.^{33,34}

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CHAPTER 16 Electrosurgery and Hemostasis

Michael Frank
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SUMMARY

- Electrosurgery is a workhorse technique for dermatologic surgeons, with electrocautery and electrodesiccation representing the most frequently used techniques.
- Monoterminal units that function without a ground may be useful for many applications, but generally cannot be used for high-power applications or electrosection.

- Electrosurgery is a staple of dermatologic surgery practice, whether used for hemostasis, treatment of nonmelanoma skin cancer, or benign lesion desiccation.

Beginner Tips



- For most applications, electrocoagulation is the standard setting, and can be used with a monoterminal unit.
- Generally 40 watts is sufficient for small-vessel coagulation.

Expert Tips



- Electrosection may be useful for wide undermining.
- Do not use electrosection on any tissue that will be sent for histopathologic analysis in order to minimize the risk of artifact.
- Electrofulguration is an elegant technique in experienced hands to treat seborrheic keratoses, but as no tissue will be available for pathology the diagnosis must be absolutely certain before proceeding.

Don't Forget!



- Biterminal units always require that patients be in contact with a grounding plate, and most modern units are well isolated.
- Monoterminal units should never be used on sedated patients.
- Do not attempt to use ED&C to treat areas with a thin dermis, where full-thickness wounds will result.

Pitfalls and Cautions



- Larger electrosurgical units may generate significantly more power than smaller hyfrecators used in many offices.
- Never overreach by attempting to use electrosurgical approaches on a vessel that should be ligated with suture.

Patient Education Points



- Cure rates for low-risk nonmelanoma skin cancers with ED&C are very high, but are also highly operator dependent.

- Patients should realize that the tradeoff for a quick ED&C procedure is that the healing time postoperatively may be significantly longer than seen for surgical excisions.

Billing Pearls



- ED&C coding is based on the site and size of the entire skin cancer that was destroyed.
- Multiple sites treated in the same session would be added together for size, rather than billed individually.

CHAPTER 16 Electrosurgery and Hemostasis

INTRODUCTION

For millennia, heat has been used to treat tissue and control bleeding. Over time, the methods used have evolved, with the first widely available commercial electrosurgical unit released in the 1920s. Since then, the units have been refined dramatically, though the basic concept behind electrosurgery has remained the same. Details regarding the physics underpinning electrosurgical devices have been explored at length.¹⁻⁴

Terminology

Electrosurgery refers to the passage of high-frequency alternating electrical current through tissue to achieve a desired surgical effect, such as coagulation or cutting ([Table 16-1](#)). All true electrosurgical devices utilize a high-frequency electrical generator and two electrodes. Electric current flows from the active electrode through the patient's body and returns to the electrosurgical generator via the dispersive (return or indifferent) electrode ([Fig. 16-1](#)). When current passes through tissue, the tissue's resistance converts the energy into heat. This differs from electrocautery, which can be conceptualized as a directly heated metallic object, such as a hot iron. In electrocautery, instead of current flowing through the patient's body, electrical current directly heats a metallic probe that is then applied to the tissue ([Fig. 16-2](#)). Since no current passes through the patient, electrocautery is most commonly used when the operative site is near a patient's pacemaker,

defibrillator, or deep-brain stimulator, or to limit destruction to only the superficial tissue layers, since no heat is generated in deeper tissue.

Table 16-1. Common Methods of Electrosurgery and Their Definitions

Method	Definition
Electrosurgery	Electrical current is passed through tissue to achieve a specific surgical effect (i.e., cutting or coagulation)
Electrocautery	Electrical current heats a metal probe which is then applied to tissue
Electrocoagulation (contact coagulation)	Tissue is heated below the boiling point undergoing thermal denaturation
Electrodesiccation	At the end of coagulation, there is vaporization of the water content and drying of the superficial tissue layers
Electrofulguration (noncontact or spray coagulation)	Instead of making direct contact with the tissue, the active electrode is held a few millimeters above the tissue and electric current bridges the air gap as a spark
Electrosection	The tissue is quickly brought to a temperature above its boiling point causing tissue fragmentation and cutting
Electrosection, pure cutting	With pure cutting there is minimal/no coagulation of the incisional wall
Electrosection, blend cutting	With blend cutting there is more coagulation of the incisional wall
Bipolar electrosurgery	There are two active electrodes
Monopolar electrosurgery	There is one active and one return (dispersive) electrode
Biterminal electrosurgery	The active and return electrodes are in direct contact with the patient's body
Monoterminal electrosurgery	While the active electrode is in direct contact with the patient's body, the return electrode is not. It is connected to the earth and the earth acts as the return electrode

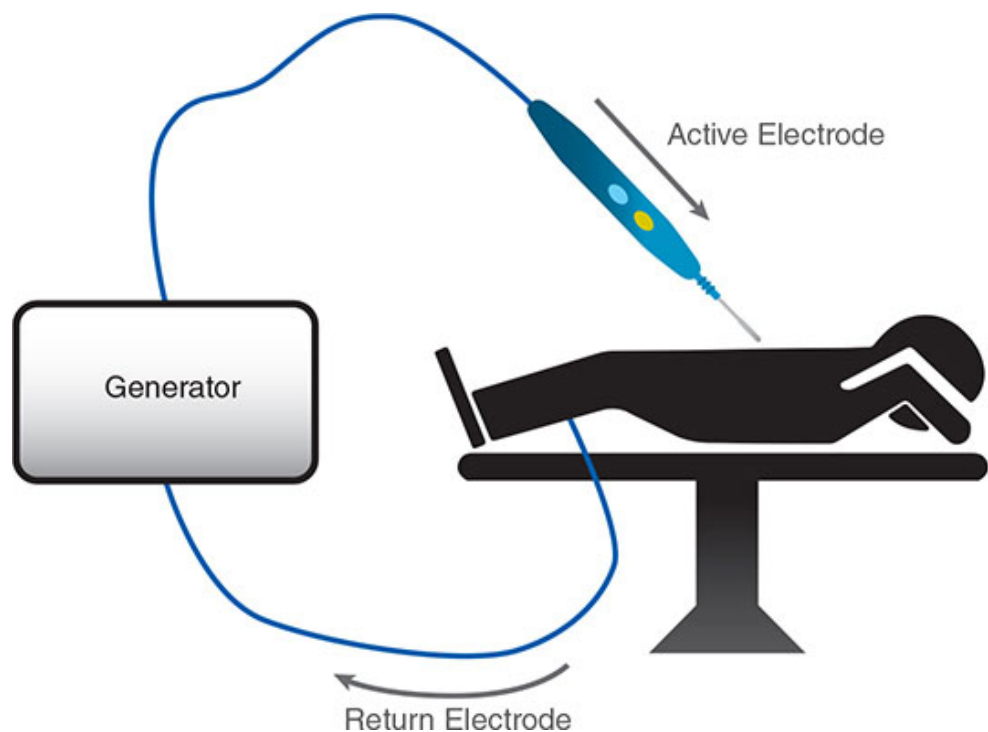


Figure 16-1. An electrosurgery unit. Current flows from the generator, through the active electrode and into the tissue. The tissue's resistance converts this energy into heat. The current then returns to the generator by way of a return (dispersive or indifferent) electrode.

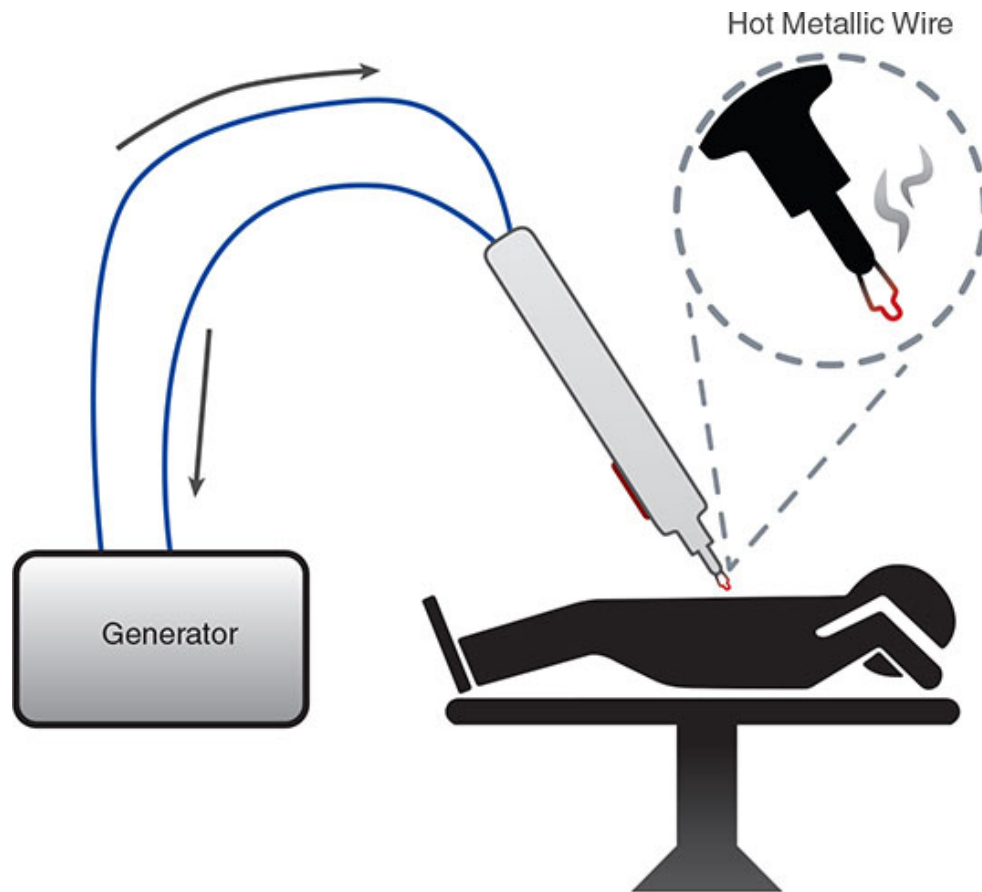


Figure 16-2. An electrocautery unit. Unlike in electrosurgery, current simply heats the tip of the electrode, which is then applied directly to the tissue to heat the superficial tissue layers.

In electrosurgery, a small active electrode delivers electrical current to the surgical site. The current is concentrated in a small area providing high current density to induce heating and thermal tissue damage.^{5,6} A return electrode attached to the patient's body then collects and disperses this current at a reduced current density that does not induce tissue heating.

Electrocoagulation is the process whereby tissue undergoes thermal denaturation through the heating of tissue below its boiling point.⁶ Additional slow heating vaporizes the water content in the coagulated tissue causing tissue drying, also known as desiccation. As superficial coagulated tissues dry out (desiccate), they become less electrically conductive, thereby preventing current from flowing and heating deeper tissue and thereby limiting the depth of coagulation.

In electrosection, tissue adjacent to the electrode is rapidly increased in temperature above its boiling point. This causes a rapid explosive

vaporization of the water content in the targeted tissue coupled with tissue fragmentation. This tissue fragmentation permits the electrode to pass through the tissue and function as a cutting instrument.⁷⁻⁹

A range of electrosurgical devices are available for dermatologic surgery. These range from simple desiccator units (Fig. 16-3) to high-powered operating room ready multifunction devices (Fig. 16-4).



Figure 16-3. A simple electrodesiccation unit. This device is appropriate for almost any dermatologic surgery application.



Figure 16-4. A high-powered electrocautery unit.

ELECTROCAUTERY MODALITIES

Electrosection

Electrosection is the cutting of tissue with current rather than a scalpel. The goal in electrosection is for the cutting of tissue to be brisk, with the lowest effective power setting.^{8,9} If the power is too low, the cutting process will be slow, resulting in a prolonged contact time with greater heating of the incision walls and therefore higher collateral tissue damage. In order to determine the correct output power for a clean incision, start low and increase the power until the maximum cutting speed is achieved. If the power is insufficient, the electrode will not easily glide through the tissue but rather will “stick.”¹⁰ If there is arcing or sparking across the tissue surface, the voltage is too high and needs to be reduced. Once the optimal power setting is determined, the same setting can be used for all subsequent patients with only mild fine-tuning required.

Electrosection is infrequently used in dermatologic surgery due to histologic distortion and a lack of evidence that it is superior to scalpel-based surgery. Electrosurgery causes greater collateral tissue damage, and therefore histologic distortion of surgical margins, compared to scalpel surgery. Thermal damage causes carbonization at the excision margin, collagen denaturation, and vessel thrombosis.^{11,12} It can cause vacuolar degeneration, along with shriveled and shrunken cell outlines with

condensation and elongation of the nuclei and fusion of cells into structureless, homogenized masses with a hyalinized appearance.¹³ All of these factors may result in false positives due to normal structures mimicking tumor.¹⁴ Therefore, when electrosection is used in the context of dermatologic surgery, it is usually performed as a wide undermining technique for large excisions.

When electrosection units first came to market, reports of impaired wound healing and increased postoperative infection rates discouraged their adoption by dermatologic surgeons. As such, there is very little data comparing electrosection to conventional scalpel surgery with respect to incisional speed, postoperative pain and infection, wound healing, or scar cosmesis. The few randomized control trials that do exist are found in the general surgery literature. Not surprisingly, electrosection is associated with significantly less blood loss and shorter incisional time, though it is unclear whether it is associated with any statistically significant difference in postoperative pain, infection, wound healing, or scar cosmesis.^{15,16}

Electrocoagulation

Electrocoagulation can be performed in two manners: contact mode or spray (fulguration) mode. In contact mode, the depth of coagulation is proportional to the size of the electrode tip and its associated power (Table 20-2).

Table 16-2. Factors Affecting Depth of Coagulation

Size of the electrode tip
Power setting
Duration the electrode is in contact with the tissue

For superficial coagulation of small areas (i.e., destruction of small seborrheic keratoses or warts), a fine-tipped electrode should be used. The fine tip concentrates the current to a fine point, allowing the surgeon to use lower power. When using a fine-tipped electrode, the current density in the tissue rapidly decreases with the increasing distance from the electrode. As a result, heat generation is confined to the narrow vicinity of the electrode tip,

allowing targeted heating of the superficial lesion while decreasing the chance of dermal heating, damage, and subsequent scarring.¹⁴

For deeper coagulation, a large-tipped electrode (i.e., a ball- or disc-shaped electrode) and higher power should be used. A large-tipped electrode is effective for deep coagulation but not superficial coagulation because unlike with a fine-tipped electrode, where current density rapidly decreases with the increasing distance from the electrode, current density slowly decreases with the distance, and thus a larger and deeper area is heated. Large-tipped electrodes are, therefore, only indicated for deep coagulation (i.e., destruction of deep reticular dermis after curettage in the setting of destruction of a nonmelanoma skin cancer).

Electrofulguration

Electrofulguration is useful in the setting of coagulation of large superficial areas (i.e., to destroy a large seborrheic keratosis or achieve hemostasis in an oozing field). In electrofulguration, the active electrode is held a few millimeters above the tissue. A spark, or arc of electricity, then jumps from the electrode to the tissue where it moves rapidly from location to location. Unlike using the contact mode, the current is therefore spread superficially over an area larger than just the tip of the electrode.¹⁷

In electrofulguration, each spark acts like an exquisitely fine electrode. The spark itself is high temperature, so it induces tissue destruction and coagulation at the site of contact. However, the temperature rapidly decreases with the increasing distance from the spark itself. Consequently, tissue charring is restricted to superficial tissue. If one wishes to achieve deeper heating and coagulation, this can be achieved by keeping a fulgurating electrode over a confined area for a prolonged period of time. Continuous heating of the superficial layers causes heating of the deeper layers.

Electrodesiccation

During electrocoagulation, especially when performed slowly, the more superficial tissues may dry out. This is called desiccation. This step is important because the current may decrease or stop flowing entirely, limiting the maximum depth of coagulation. When this occurs, a popping sound or

sparkling may occur through the dried nonconductive layer, exploding and fragmenting the dried layer. Desiccation is not guaranteed, does not always happen, and the time to onset is unpredictable. The timing at which desiccation occurs during the course of coagulation is dependent upon the rate of increase in temperature. This is determined by current density. A low current density can allow for a deeper coagulation before the onset of desiccation.⁶ Therefore, in the setting of deep coagulation (i.e., after curettage of a malignant lesion), a low power should be used. With no published data, a rule of thumb is to choose a power which can provide desiccation (popping sound) after 4 to 7 seconds to achieve relatively deep destruction.

There are three factors that influence the depth of coagulation: the size of the electrode tip, the power setting, and the length of time for which the electrode is in contact with the tissue. The longer the electrode is in contact with the tissue, the more heat is generated and the wider and deeper the tissue damage.

Utilizing a lower power with a longer contact duration is not preferable to adopting a higher power with longer contact duration. Longer contact time conducts more heat, leading to increased collateral tissue damage before the desired outcome is attained.^{18–20} This is much the same concept as when choosing pulse duration for a laser. Therefore, to minimize collateral tissue damage, the contact time should be minimized or divided into multiple pulses to allow the tissue to cool between pulses.

Bipolar versus monopolar electrosurgery

The prefixes monopolar and bipolar refer simply to the number of *active electrodes*. In monopolar electrosurgery, an active electrode transfers current to the tissue where it spreads throughout the body before being collected and returned to the electrosurgery unit by a dispersive (return or indifferent) electrode. Often the dispersive electrode is a plate that the patient either grips or is otherwise in contact with. In bipolar electrosurgery, the active electrode is a pair of forceps. Electrical current flows from the active prong through the grasped tissue and into the dispersive (return) prong where it flows back to the electrical generator. Bipolar electrosurgery may be safer

for the patient, since there is less damage to the surrounding tissue and lower risk of distant site burns when compared to monopolar electrosurgery.^{21,22}

Biterminal versus monoterminal electrosurgery

The prefixes monoterminal and biterminal refer to the number of *electrodes in contact with the patient's body*. Bipolar electrosurgery is always biterminal, whereas monopolar electrosurgery may be monoterminal or biterminal.

In monoterminal electrosurgery, there is no dispersive electrode connected to the patient's body. Instead, the return electrode is connected to the earth, often through the power supply cable. These are known as earth-referenced units. These monoterminal units are ubiquitous in medical dermatology suites. However, it is important to note that if an electrically conductive object, such as a metal table or electrocardiogram electrode, makes contact with the patient's body, some current may pass through this object on its return pathway to the ground. If the contact area is small, the current may be concentrated enough to cause a focal burn at the site. Therefore, these devices should only be used on conscious patients who are able to alert the surgeon to such complications, and on insulated tables with no exposed metal parts near the patient's body.

The most common electrosurgical unit used in operating rooms today is a floating or isolated biterminal unit. Unlike earth-referenced units, the dispersive electrode is isolated from earth. Therefore, current will only flow if there is a dispersive electrode attached to the patient.²³ As a result, if the patient comes in contact with a conductive environmental object, minimal to no current will pass through that object, and therefore the risk for burning is minimal. Additionally, the surgeon is protected, since one can touch the active electrode and as long as they do not touch the patient or the dispersive electrode, there is no risk of the surgeon sustaining a burn.

RISKS AND CAUTIONS

Electrosurgery in the setting of cutaneous surgery is very safe, but it is still not without risk. These risks include burns, infection, ocular injury, and cardiac pacemaker, defibrillator, or deep-brain stimulator malfunction.

Electrical burns

Electrical burns occur when high current density flows through a small surface area. This usually happens when there is faulty application of the indifferent electrode, the patient makes contact with a metal surface, or there is current channeling to a distant site.

Improper placement of the indifferent electrode includes placing it over a bony prominence, scar tissue, or metal implants, or when too small of a surface area of the indifferent electrode is in contact with the patient. Current becomes concentrated in this small surface area, resulting in high current density. If this high current density is allowed to continue for too long, then an electrical burn occurs. A patient would normally experience pain and discomfort prior to experiencing a focal burn, but if the area is anesthetized they may not.^{6,23–25}

A patient is also at risk for burns if he or she makes contact with a grounded metal object while electrocautery is occurring. This is especially true when the indifferent electrode is broken or improperly placed, or when using a monoterminal unit. This is because current seeks any alternative low-resistance pathway from the patient to the ground.

Another cause of burns is a phenomenon known as current channeling. This is when current is concentrated as it flows through a small area. For instance, if applying current to a mass with a narrow base or stalk, such as a fibroepithelial polyp, as the current flows into the narrow stalk it is concentrated. This concentrated current can cause a burn at the site of the base of the lesion.^{26,27}

The threat of burns can be mitigated through a few simple precautions. Never leave an active electrode on a patient when not in use. A patient should always be in contact with at least 20 square inches of the indifferent electrode to ensure sufficient current dispersion. This is made easier by flexible indifferent electrodes that conform to the body, the use of protective interface gels, and contact quality monitors. Many modern electrosurgery units have a contact quality monitor for the dispersive electrode. It measures the quality of contact between the patient's skin and the dispersive electrode as well as between the electrode and the generator. However, there is no clinical evidence to support the notion that a contact quality monitor minimizes the risk of burns.¹⁰

Never use a bent indifferent electrode, as this can create a sharp point that concentrates current. Make sure the patient is not in contact with any metal surfaces. If the patient has any metal in his body, the dispersive pad should be placed between the metal and the surgical site to prevent current from passing through the patient's implanted device. When treating a pedunculated lesion for which there is risk of channeling, use bipolar forceps or wrap a saline-soaked sponge (an electrolyte conductor) around the stalk.²⁶⁻²⁸

Infection risk

In experimental settings, electrodesiccation has been associated with transmission of human papillomavirus (HPV), hepatitis B virus, and *Staphylococcus aureus*. Some people erroneously think that the heat induced by electrocoagulation sterilizes the electrode tip. This is true in electrocautery where heat is generated in the tip but not in electrocoagulation where heat is only produced in the tissue. Special precautions in the form of facial masks, protective eye wear, and a smoke evacuator should be used when treating HPV-related lesions, since HPV can become aerosolized in blood micro-droplets and in electrosurgical smoke posing a risk to the patient, physician, and surgical staff (Fig. 16-5).²⁹⁻³¹



Figure 16-5. Smoke evacuation systems are a useful adjunct to electrosurgery.

Eye injury

When operating in the periorbital area, patients should wear nonmetallic corneal shields, since sparks may arc toward the globe causing corneal damage and scarring. The corneal shields must be plastic rather than metal to prevent conducting the current toward the globe.³²

Cardiac pacemaker, defibrillator, or deep-brain stimulator malfunction

Electrosurgery has the potential to interfere with cardiac pacemaker, implantable cardioverter–defibrillator (ICD), or deep-brain stimulator function. Pacemakers are generally classified as fixed rate or demand type. Fixed-rate pacemakers fire at a predetermined rate irrespective of the

intrinsic cardiac rhythm. Demand-type pacemakers fire at a predetermined rate only in the absence of intrinsic cardiac rhythm. Demand-type pacemakers are further subdivided into ventricular inhibited or ventricular triggered. The ventricular-inhibited, demand-type pacemaker is the most common pacemaker in the United States.

Since fixed-rate pacemakers fire at a fixed rate regardless of intrinsic cardiac rhythm, they lack sensing circuitry. Consequently, exogenous electrical signals from the active electrode pose no threat to the patient. Conversely, all demand pacemakers contain sensing circuitry and are therefore susceptible to interference from extraneous electrical current. The function of demand pacemakers is to prevent bradycardia and asystole. The ventricular-inhibited pacemakers do this by firing when the patient's intrinsic cardiac rhythm is slower than the preset rate. A ventricular-triggered device fires with each spontaneous heartbeat as well as at a predetermined rate in the absence of intrinsic rhythm.^{28,33}

The electromagnetic output of electrosurgery can interfere with the sensing circuitry of demand pacemakers causing them to erroneously perceive the electrical current from electrosurgery as spontaneous ventricular contraction. In the setting of a ventricular-inhibited pacemaker, the pacemaker perceives this electrical current as a spontaneous heartbeat and erroneously enters stand-by mode. This can cause bradycardia and asystole leading to syncope, seizure, or death. In a ventricular-triggered device, the electrical current is misread as a spontaneous heartbeat causing the pacer to falsely stimulate ventricular contraction. This can cause life-threatening tachyarrhythmias or ventricular fibrillation. Although any electrosurgical procedure poses a risk for pacemaker-related complications, electrosection poses the highest risk.^{31,33}

An ICD is a device that sends a defibrillatory shock to the heart if it senses tachyarrhythmia or ventricular fibrillation. It is usually inserted into an abdominal or infraclavicular subcutaneous pocket. Electrosurgery can cause an ICD to erroneously shock the heart, which is not only excruciatingly painful to an alert patient but can induce life-threatening tachyarrhythmias. Electrosurgery can also damage the ICD device itself.³¹

A deep-brain stimulator is an implanted device that generates electrical impulses to control movement disorders such as essential tremor or Parkinson's disease. An electrode implanted in the brain is connected to a

pulse generator that sits in a subcutaneous pocket in the chest, much like an ICD. As with an ICD, electrosurgery can interfere with functioning of the brain stimulator.

Electrosurgery in the setting of pacemakers, ICDs, or deep-brain stimulators poses life-threatening complications, but how common are they? A survey study of 166 Mohs surgeons with a total of 1959 years of experience examined the number and type of complications due to electrosurgery. The incidence of interference was exquisitely low with 1.6 cases/100 years of surgical practice. The incidence of clinical adverse events was even lower at 0.8 cases/100 years of surgical experience. There was no significant morbidity or mortality. The 25 cases of interference were broken down as such: 8 patients experienced skipped beats, 6 patients had spontaneous reprogramming of their pacemaker, 4 patients had their ICD fire, 1 patient had a shortening of his pacer's battery life, and 1 patient experienced tachyarrhythmia. Of these 25 cases, 18 of the patients experienced a clinical adverse outcome: 6 had syncope, 5 had altered sensorium, 3 experienced palpitations, 3 required an outpatient cardiology consult, and 1 experienced hemodynamic instability.²⁹ There are only two reports of deep-brain stimulator interference.³⁴

Despite this data, several groups, including the American Society of Anesthesiologists, recommend that the patient's cardiologist be consulted prior to using monoterminal electrosurgery, and that devices be interrogated within a month after any monoterminal electrosurgical procedure, though the degree to which these suggestions are followed is unknown.³⁵

Still, the use of electrosurgery in patients with implanted devices is very safe. This is in part due to the fact that modern-day pacemakers are designed with metallic covers and filters to protect the device from external electrical interference, and therefore minimize the risk of malfunction. However, precautions should still be taken. Place the grounding electrode at a site far from the heart and pacemaker and try to avoid having the heart lie directly in the path between the treatment and indifferent electrode. Keep electrosurgical current bursts to less than 5 seconds. If operating near a pacemaker or ICD, utilizing electrocautery or biterminal forceps will avoid or minimize current leakage in the patient. Similar precautions should be taken with patients who have cochlear implants.

Persistent bleeding

While electrosurgery is well suited to the cauterization of small blood vessels, larger vessels, and even some smaller arterial vessels, may not respond definitively to electrosurgical approaches. This may be immediately obvious, as when persistent bleeding remains even after repeated attempts at electrocoagulation; more insidiously, some larger vessels will initially appear to be effectively treated with electrosurgical approaches only to persist in bleeding in the postoperative period. Therefore, less-experienced dermatologic surgeons should err on the side of ligating larger vessels. This may be accomplished in a number of ways; see [Chapter 13](#) for a detailed discussion of suturing techniques for vessel ligation.

ELECTROSURGERY FOR REASONS OTHER THAN HEMOSTASIS

Electrosurgery and hair removal

There are two mechanisms by which hair removal can be achieved through electrosurgery: electrolysis and thermolysis. In electrolysis, a needle electrode is placed into the hair follicle and a direct electrical current (galvanic current) is then applied resulting in a chemical reaction that destroys the hair follicle. In thermolysis, alternating current is applied and the hair follicle is destroyed through thermal damage. Thermolysis is faster than electrolysis, though there is a greater risk of damage to the dermis and ensuing scar formation.^{36–38} These are time consuming but are effective methods of hair removal for nonpigmented hairs or in patients with pigmented skin.

Electrosurgery for the treatment of malignant skin lesions

Electrodesiccation and curettage (ED&C) is a common and effective treatment for benign and superficially invasive neoplasms.^{39–41} In the right setting, it is quick with less morbidity and cost than surgical excision. It

involves two to three cycles of curettage followed by electrodesiccation. The ideal scenario for ED&C is a broad, superficial lesion in an area with thick underlying dermis, that is, the trunk or extremities. ED&C is not an ideal treatment modality for lesions that have the potential for follicular extension, as they are at higher risk for recurrence.^{1,42–47}

Basal cell carcinoma is perhaps the most common neoplasm treated by ED&C. Recurrent or micronodular/morpheaform basal cell carcinomas should be treated surgically through excision rather than ED&C because they are at increased risk for having deep dermal infiltration. The cure rates with ED&C are highly operator dependent, with cure rates ranging from 88% to 99%. The studies that report the highest cure rates also utilize the largest reported safety margins, ranging from 2 to 8 mm.⁴⁷ A meta-analysis of basal cell carcinomas treated by ED&C reported a weighted average 5-year recurrence rate of 8%.⁴⁸

One study examined the determinants of 5-year recurrence rates of 2314 primary basal cell carcinomas treated by ED&C between 1955 and 1982. The only variables that impacted occurrence rate were lesion size and location. Patient age, sex, or duration of the lesion had no impact. Researchers divided the body into three categories: high-, middle-, or low-risk anatomic sites. The high-risk sites included the nose, paranasal, nasolabial fold, ear, chin, mandibular, perioral, and periocular areas. Middle-risk sites were the scalp, forehead, pre- and postauricular, and malar areas. Low-risk sites were the neck, trunk, and extremities. Lesions that were ED&C'd in low-risk areas had a 3% recurrence rate within 5 years regardless of the lesion's diameter. Middle-risk sites had a 5-year recurrence of 5% for lesions <10 mm in diameter and a 23% risk for recurrence with lesions >10 mm. High-risk sites had a 5-year recurrence rate of 5% for lesions <5 mm and 18% for lesions >6 mm.⁴⁹

Step-by-Step Approaches

Hemostasis with monopolar electrocautery

1. Defer hemostasis until the lesion is completely excised and appropriately undermined.

2. In order to achieve complete hemostasis, visualization of the wound bed and undermined surface should be achieved via skin hooks and ample gauze.
3. For electrocoagulation to work effectively, the operative field must be dry, as blood diffuses the current flowing from the electrode. A dry field is best achieved utilizing a two-handed technique. With the nondominant hand, use forceps and a piece of gauze to dry the field and visualize the source of bleeding. With the dominant hand, cauterize the source of bleeding with the active electrode. If possible, an assistant should hold gauze at the dependent area of the wound to absorb any dripping blood.
4. It is easiest to achieve hemostasis by operating in the direction of gravity. For instance, if operating on the neck, work from the superior to the inferior pole.

Achieving hemostasis with bipolar electrocautery

1. Dry the field to visualize the sites that are bleeding.
2. Clamp the tines of the bipolar electrode, shut and touch it to the areas that are bleeding.

Achieving hemostasis of a bleeding vessel

1. Use gauze to dry the field and visualize the bleeding vessel.
2. Using fine-toothed forceps or a hemostat, grip the vessel, then touch the active electrode to the forceps or hemostat and apply monopolar current through it.
3. If using a bipolar electrode, simply grip the vessel between the two tines and apply current.
4. If a popping sound is heard or a spark is seen, current flow should be stopped and the area re-evaluated to ensure satisfactory hemostasis. In order to optimize hemostasis, the surgical field should be dry, as blood will diffuse the current flowing from the electrode.
5. Only small vessels should be cauterized in this fashion; larger or arterial vessels would benefit from direct suture ligation.

How to perform electrodesiccation & curettage

1. Anesthetize the area with a mixture of 1% lidocaine with epinephrine.
2. With the sharp end of the curette pointing down toward the skin, scrape the affected area to the base, which can be identified by the gritty sensation of the dermis. In the setting of a skin cancer, the cancerous area is more friable compared to normal skin.
3. Dry the base with gauze, then fully electrodesiccate the base with electrosurgery.
4. Recurette the base in a different direction and once again desiccate the base. Repeat for a total of three passes.

Another consideration to take into account when deciding upon whether or not to treat a lesion by ED&C is cosmesis. On the trunk and extremities, ED&C most often results in residual dyspigmented patches, though atrophic, hypertrophic, or keloidal scars can occur. On the face, ED&C often produces a fine white macule or patch, while indurated or depressed circular scars are a risk. For many patients, ED&C offers a cosmetically acceptable scar.^{47,49}

Electrosurgery for the treatment of benign epidermal lesions

Benign skin lesions such as seborrheic keratoses or warts can be treated with superficial coagulation by using a fine-tip electrode or electrofulguration with very low power. After a quick, gentle treatment, the lesion should be wiped off. If there is any residual lesion left, a subsequent pass of superficial electrocoagulation can be performed. If there is spark formation, this is an indicator of deeper injury. This can be avoided by reducing the voltage, power, or contact time.

CONCLUSIONS

Electrosurgery is a universal staple of the dermatologic surgery practice, whether used for hemostasis, treatment of nonmelanoma skin cancer, or benign lesion desiccation. A comprehensive appreciation of the underlying principles behind electrosurgery helps the dermatologic surgeon better decide on optimal techniques and approaches for a variety of applications.

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CHAPTER 17 Incision and Drainage

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SUMMARY

- I&D may be used to treat various conditions that require the release of enclosed contents, such as hematomas, furuncles, and infected cysts.
- Placing the incision parallel to relaxed skin tension lines may mitigate the appearance of more prominent scars.

- While these procedures are straightforward and can be performed with great rapidity, a poorly performed I&D procedure may serve only to exacerbate an already unpleasant or even dangerous condition.

Beginner Tips



- Choose the most fluctuant area of the lesion, which represents the most liquefied portion of exudate, for easily drainage.
- Choosing the dependent area to facilitate drainage by gravity effect may also reduce the need for manual pressure and attendant patient discomfort.
- Thicker exudate such as blood, coagulum, or mucin requires a longer time to start draining.

Expert Tips



- An 18G needle can be useful for I&D on very small lesions. Due to the small opening of this type of incision, thick exudate may not drain out easily. After stabbing, keep the tip of the 18G inside the lesion, push the needle tip laterally to widen the slit-like cut, and wait for exudate to drain.

- Collect fresh, uncontaminated exudate for swab culture to improve the accuracy of culture and sensitivity; avoid collecting the skin surface–contaminated exudate. Allow the exudate to be collected to drain without running on the skin by compressing the lesion and holding the tip of the swab at the proper position and angle.

Don't Forget!



- If no or minimal drainage occurs, assess the patency of the incision site.
- Inject lidocaine in the superficial dermis, not into the lesional cavity. Pain with incision may occur when lidocaine injection occurs inside the lesion instead of the dermis and adjacent subcutaneous tissue. A ring block can also be considered.

Pitfalls and Cautions



- The incision should be stopped as soon as the surgeon senses low tissue resistance, in order to avoid tissue damage at the base of lesion.
- Bleeding at incision sites is common. Use external compression to control bleeding.

Patient Education Points



- I&D is a fast and effective procedure, but does not guarantee that a given fluid collection will not recur.
- For inflamed or infected cysts, patients should be warned to expect recurrence, and definitive excisional surgery may be needed in the future.
- I&D requires significant postoperative care, as wounds generally need to be packed or cared for in other ways. Patients should understand that postprocedure management is a process, and drainage may persist for longer than anticipated.

Billing Pearls



- I&D of an abscess is most frequently coded using CPT code 10060. When draining multiple abscesses, 10061 may be coded, and this code may be used for “complicated” lesions as well, though its use should clearly be justified in the body of the surgical report. Additionally, 10140 may be used for nonabscess I&D. The 10160 code may be more appropriate when performing I&D using an 18G needle alone.

CHAPTER 17 Incision and Drainage

INTRODUCTION

Incision and drainage (I&D) is commonly performed in both general and procedural dermatology outpatient settings. This approach may be utilized to treat various conditions that require the release of enclosed contents, such as hematomas, furuncles, infected cysts, and collections of other extraneous substances. While the advantage of I&D is that it is easy to perform, patients should be warned regarding the requirement of postprocedural care. Moreover, since expression of the entire cyst wall is rarely effected when treating inflamed or infected cysts, recurrence of such lesions may be seen (Tables 17-1 and 17-2).

Table 17-1. Indications for Incision and Drainage

Hematoma
Carbuncle or furuncle with fluctuance
Acute paronychia with abscess
Inflamed epidermal inclusion cyst
Dissecting cellulitis with exudate collection
Hidradenitis suppurativa with abscess
Pseudocyst of the auricle
Acne cyst
Digital mucous cyst
Mucocele
Seroma postsurgery
Trapped blood coagulum from sclerotherapy

Table 17-2. Advantages of Incision and Drainage

Evacuates the infectious material containing the pathogen
Enhances antibiotic diffusion into the local tissue improving their efficacy after release of buildup pus or exudate
Removes accumulated blood, which may act as a nutritional source for bacterial infection
May enable visualization of the bleeding site in active hematoma
Facilitates specimen collection for culture and sensitivity
Decreases inflammation associated with accumulation of inflammatory exudate
Opens and collapses the pocket space, minimizing recollection of the exudate; promoting healing (fibrosis)
Rapidly decreases the size of lesions improving their appearance; easing cosmetic concerns

There are no absolute contraindications for I&D. Abscesses of the palms and soles can be associated with complications, and may require

consultation with an appropriate surgical specialist. In select cases, I&D may be best performed in an operating room with conscious sedation. These include extremely large abscesses, complicated skin and soft tissue infection involving deeper invasion of tissue, or deep abscesses in areas that are difficult to anesthetize.

Patient education and evaluation

Patient evaluation should include inquiry as to history of lidocaine allergy, latex allergy, and hypertrophic scars or keloids. Further, the patient's expectations of the cosmetic outcome should be discussed. Informed consent should be obtained and the patient should be counseled regarding the risks, benefits, and alternatives of the procedure, as well as potential risks of not undergoing the procedure (e.g., acute abscesses). Risks include, but are not limited to, infection (new or worsening of existing infection), bleeding, pain, nerve damage, and scar formation (keloids and hypertrophic scars).

Procedure overview

All equipment should be placed within reach, ideally on a Mayo stand. Adjust the lighting to allow easy visualization of the abscess.

Choose the incision site in the most fluctuant and prominent part of lesion, where the contents appear most liquefied, in order to permit rapid and effective drainage. In addition, consider starting with the most dependent portion of lesion for the ease of drainage utilizing gravity effect. The patient should be properly positioned so that the area for drainage is fully exposed and easily accessible, while ensuring the patient's comfort.

Apply a topical antiseptic (alcohol, povidone–iodine, or chlorhexidine) to the entire lesion and particularly to the area to be incised, followed by application of a sterile drape as indicated. Avoid using chlorhexidine in the ear and periorbital areas.¹

An absorbent pad, gauze, or chuck is placed to protect other areas from draining exudate. Placement of a cotton ball or dental roll inside external ear canal is recommended to protect the ear from draining exudate. Gloves, gown, and a face shield should be worn at all times during the procedure to avoid exposure to bodily fluids, particularly from high-pressure abscesses.

Local anesthesia is injected into the selected incision site and around the lesion to minimize both the tenderness associated with pressure as well as the incision proper. This is achieved with infiltration of 1% to 2% lidocaine with or without epinephrine using a 30G needle. Care should be taken to deliver anesthetic solution into the skin overlying the lesion instead of infiltrating lidocaine into the cavity. Needle insertion is just under and parallel to the surface of the skin, and anesthetic is injected into the intradermal and subcutaneous tissues until blanching of the tissue is noted as the anesthetic diffuses. In patients with lidocaine allergy, alternatives can be employed. For a more detailed discussion of anesthetic choices, see [Chapter 12](#).

Nerve block or local field block may be required for larger and deeper lesions to ensure the patient's comfort. A ring block may permit anesthesia of the entire target area without directly injecting local anesthetic over the fluctuant mass, which may mitigate the risk of spray back. This approach, however, also does not infiltrate any epinephrine into the area to be incised, so an attendant increased risk of mild bleeding may be anticipated. Adequate anesthesia is essential for complete and thorough drainage. Depending on the patient's pain threshold, ice cubes, ethyl chloride spray, or topical anesthesia may be helpful if applied prior to injecting lidocaine to decrease discomfort delivering local anesthesia. This is particularly important as the acidic environment of infected tissue may make it more difficult to achieve sufficient anesthesia with local agents.

When approaching small digital mucous cysts and trapped blood coagulum following sclerotherapy, I&D may be performed by rapid single puncturing with a needle, and local anesthesia may not be needed. Lidocaine injection may blanch the area or otherwise make these lesions more difficult to visualize for I&D. Ice cube, ethyl chloride spray, or topical anesthesia used instead of lidocaine injection may be better for such lesions. Injectable lidocaine is necessary, however, when I&D of a digital mucous cyst is followed by destruction using electrodesiccation.

INCISION

For smaller lesions, a #11 surgical blade is used to incise the selected and anesthetized area. It is commonly used for I&D due to its sharply pointed tip

which is well suited for a perpendicular stabbing approach into the lesion, though if unavailable any blade, such as a #15 scalpel blade, will suffice. Following the initial stab to enter the cavity, the incision is extended to create an opening large enough for drainage, which is dependent on the consistency of exudate, and to prevent recurrence of lesion (recollection). For lesions of larger size and in certain locations (e.g., deeper set lesions on the back), a #15 or #10 surgical blade may be utilized preferentially.

Placing the incision parallel to relaxed skin tension lines may mitigate the appearance of more prominent scars. Care should be taken that the incision length not to be too short, restricting the ability of exudate to adequately drain, though an unnecessarily long incision will yield a more prominent scar. Err on the side of creating a shorter incision, as this can always be enlarged if needed.

Care should be taken not to overextend the depth of initial puncture incision, as accidentally stabbing through the base of the lesion's cavity may sever underlying tissue or vessels, increasing the risk of persistent infection or bleeding.² Stab incision depth should be designed only to permit the tip of surgical blade to pass through the skin and the wall of lesion; generally, once this is accomplished, there will be an immediate drop in tissue resistance, and often some of the material to be drained will appear.

Sterile cotton-tipped applicators may be inserted to gently probe the cavity down to its base and facilitate the removal of any remaining loculated or congealed fluid. Special care should be taken in making the incision if there are prominent vessels or nerves in the area, or when working close to anatomic danger zones. When incision is performed on highly vascularized area, such as a mucocele on mucosal lip, consider having an assistant apply steady pressure around the lesion while performing I&D for bleeding control and improve visualization. Care should be taken when incising high-pressure lesions, as the contents may escape explosively in a projectile manner, contaminating the surgeon and surrounding area.

Alternative approaches

Direct puncture with an 18G needle may be used in small lesions that have relatively nonviscous contents, given the relatively large bore size of the 18G needle. Contents of a digital mucous cyst or trapped blood coagulum can be

adequately drained when the tip of the 18G needle is kept inside the target space and pushed laterally away from the wound access point in order to open and enlarge the defect. The resulting rounded opening generally permits spontaneous drainage of the exudate. Care should be taken not to remove the needle immediately after puncture so that the nascent skin access point does not reclose. Patience is required with this approach, as it may require 1 to 2 minutes to see the viscous contents slowly drain out while the tip of the needle is kept in place. Importantly, the contents will not rapidly and spontaneously drain. A cotton-tipped applicator is useful to push the lateral wall of lesion outward immediately after the needle is removed to facilitate complete drainage. I&D of digital mucous cysts may be followed by other treatments such as cryotherapy or injection of sclerosing solution or triamcinolone.^{3,4}

Direct puncture with an 18G needle connected to a syringe followed by negative pressure application by withdrawing the syringe plunger can be used to drain the exudate associated with dissecting cellulitis or trapped blood coagulum of larger veins. The use of duplex ultrasound guidance is particularly helpful in avoiding local arterial injury.

Performing the incision with a punch instrument can be useful because it gives a round-shaped opening for drainage instead of a linear slit. Due to the round-shaped opening, exudate continues to drain at home after the performance of in-office I&D, which may minimize the need to insert wound-packing material. Punch incision is particularly useful in draining thick exudate such as noninflamed epidermal inclusion cysts, as releasing the keratinous content alleviates discomfort from built-up pressure.⁵ The size of the punch instrument should be commensurate with the size of lesion and the thickness of exudate. However, the greater ease of drainage associated with utilizing a larger-sized punch instrument should be weighed against the risk of a more substantial postoperative scar. In general, a punch instrument size of 4 mm or less should produce acceptable scar cosmesis.⁶

DRAINAGE

Initially, the exudate may spontaneously drain after incision is performed secondary to built-up pressure. When the lesion is incised at the most fluctuant and dependent area, thin exudate will spontaneously drain out

without the need to apply pressure to the lesion, as long as the incised area remains patent.

External pressure may be required in order to definitively drain the remaining exudate, though this may be at the expense of patient comfort. To minimize pain, it is important to apply pressure to the lesion carefully, though often the relief associated with internal pressure reduction outweighs any transient pain associated with the placement of lateral pressure. Pressure is applied gently and slowly from the lateral sides of the lesion toward the incision site (Figs. 17-1 to 17-5). Applying pressure from the top of the lesion at the incision site down to the bottom of the lesion may not result in effective drainage; indeed, the contents may move laterally toward the wall of the fluctuant mass when pressure is applied vertically, and this approach should therefore be avoided. For smaller masses, using a cotton-tipped applicator provides a better focal point of pressure than using a fingertip, which is much larger. If the patient experiences significant discomfort, additional injections of local anesthetic, possibly as a ring block, may be beneficial.

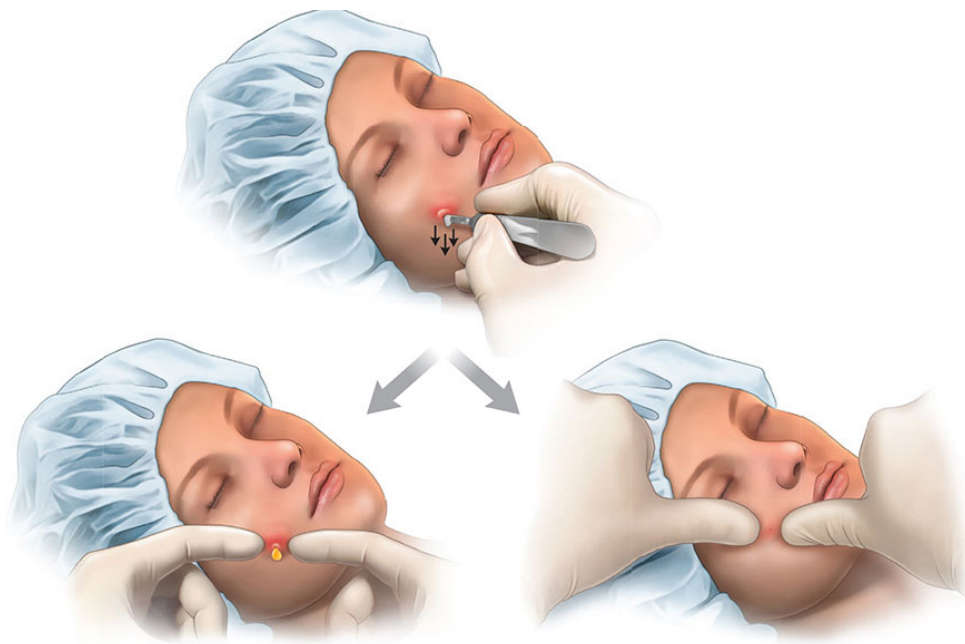


Figure 17-1. I&D on the most dependent portion of a cyst on a patient's cheek in supine position utilizing gravity effect for the ease of drainage. Note that lateral pressure (*left*) results in the extrusion of the contents, while downward pressure (*right*) does not.

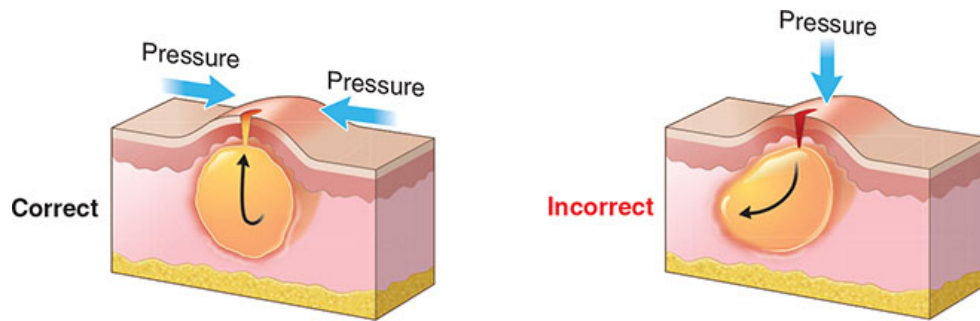


Figure 17-2. Pressure is applied gently and slowly from the lateral side of lesion toward the incision site, which moves the contents toward the exit provided by the incision. The contents may move laterally toward the wall of lesion and away from the exit when pressure is applied vertically.



Figure 17-3. A small stab incision is made at the inferior pole of the abscess.



Figure 17-4. Gentle lateral pressure is used initially to ensure that contents are effectively extruding through the incision.



Figure 17-5. Firm lateral and upward pressure is applied to force the expulsion of all cyst contents.

Curved hemostats may be used to enlarge the opening from a narrow slit-like space to a wider exit point, which is especially helpful for thick purulent

exudate. The closed tips of curved hemostat clamps are inserted into the incised area and then opened to widen the incised area. The nondominant hand is used to apply pressure to further drain the contents. Hemostats may also be used for careful blunt dissection to break up loculations and facilitate further drainage. Forceps can be used to open the exit for drainage, though they provide only minimal leverage. Care should be taken not to overly stretch and traumatize the skin edges with hemostats or forceps, as this may affect the healing and ultimate cosmesis of the incision site.

When I&D is performed on an acute hematoma, its solidity requires a larger incision and external pressure to remove the clot. Older blood collections can be drained with a shorter incision length or an 18G needle. Attention should be paid to any fresh red blood when I&D is performed on hematoma, which may indicate active bleeding that would need to be definitively surgically addressed.

For acute paronychia with an abscess located immediately adjacent to the nail sulcus, the tip of a #11 or #15 surgical blade or 21G or 23G needle may be gently inserted underneath the proximal or lateral nail folds to create an opening for drainage.^{7,8} Gentle pressure is applied to extrude the purulent exudate. Care should be taken to point the sharp edge away from the nail, and not to insert it too aggressively in order to avoid damaging neurovascular bundles, tendons, or the nail matrix. A piece of gauze may be placed underneath the nail fold to allow continued drainage.⁹ For an abscess not located immediately adjacent to the nail sulcus, incision is made directly over the abscess and/or in line with the lateral nail fold to decompress the abscess.¹⁰

If indicated, swab culture and sensitivities may be sent out using freshly drained exudate. Avoid contacting the tip of swab with skin or mucosal surface to prevent contamination by normal flora. A sterile syringe may be used to obtain a sample from the interior aspect of the cavity.

Irrigation may be performed to further remove the infectious or inflammatory exudate. The tip of a sterile, normal saline-filled syringe is inserted through the incised wound, and the cavity is gently rinsed to thoroughly irrigate the cavity until the effluent is clear. Copious quantities of gauze or absorbent pads should be placed at the site to absorb fluid and minimize splash-back over the surrounding area and operator. The nondominant hand may be used to apply gauze to cover the incised area

during irrigation. A syringe with a built-in splash shield may also be used. An appropriate incision size will enhance irrigation and prevent excessive buildup of pressure within the lesion.

If further drainage is required, wound-packing material, such as 1/4- or 1/2-inch packing strips with or without iodoform, is gently inserted through the incision site and loosely packed inside the lesional cavity using hemostats or forceps. This will prevent premature closure of the incised wound, which can lead to recollection. Care should be taken to avoid overpacking the wound, which could cause ischemia of the surrounding tissues and impede the desired drainage.¹¹

Electrodesiccation may be performed after I&D of mucoceles or digital mucous cysts to close the dead space and avoid recollection of the exudate.¹² Any active bleeding points are cauterized.

A pressure dressing may be needed on some lesions in order to collapse the cavity, minimize recollection of exudate, and minimize dead space, which could lead to reaccumulation. Dissecting cellulitis of the scalp requires pressure dressings and head wraps, as the exudate can rapidly reaccumulate. This pressure dressing may also serve to help control bleeding.

Postprocedure care

Counsel the patient on local wound care. Change the wound dressing and/or packing every 24 hours and after each shower. Petrolatum may be applied to an incised wound that does not require further drainage in order to promote wound healing.

Cover the wound with a sterile, nonadherent dressing. Apply several layers of gauze to absorb any persistent drainage, and secure the dressing with surgical tape such as paper tape.

A compression dressing may be applied if indicated.

Counsel patients regarding the likelihood of blood- or exudate-saturated gauze being present during dressing changes.

Antibiotics may be indicated for certain diagnoses, such as hematoma or infection. Preoperative treatment with antibiotics may be a helpful adjunct for the I&D of abscesses in patients who are at increased risk for endocarditis.¹³

Analgesic medications may be helpful if indicated. In general, the majority of pain and discomfort should be significantly relieved after pressure is released following I&D.

Recounsel the patient regarding the expected scar formation when the incised wound is allowed to heal by the second intention, particularly with large hematomas. Also, outline the risk of recurrence.

Follow-up may be scheduled within a few days to a week for wound check, dressing change, or packing material removal. Wound-packing material is removed when no fresh exudate is visible, and a simple dressing with gauze is then sufficient.

Instruct the patient to call and/or return before the scheduled appointment if there are any signs of worsening or infection such as redness, swelling, tenderness, or fever.

Risks of I&D and their management

The potential complications of I&D include inadequate drainage, infection, bleeding, nerve damage, hypertrophic scars, and keloids. Methods to manage these complications are summarized below.

Inadequate drainage

The drainage exit may close off too soon, resulting in inadequate drainage. This can be prevented by using wound-packing material or a punch incision technique, or by leaving a cotton-tipped applicator in place during drainage.

Infections

While abscess is one of the most frequently seen indications to perform I&D, local infection can occur in noninfectious indications of I&D as a result of the procedure itself. Purulent drainage, swelling, persistent redness, and delayed healing may be evident, and when these are noted, the patient should undergo evaluation and treatment. Management of these infections includes an appropriate topical and/or systemic antibiotic, daily wound care, and repeat I&D, if the site develops an abscess with fluctuance. Responsible organisms vary by anatomic location, though *Staphylococcus aureus* is most commonly seen.

Bleeding

Bleeding is managed by external compression. Appropriate use of hemostatic measures is essential at the site of incision as well as for obtaining adequate hemostasis within an active hematoma requiring I&D.

Hypertrophic scars or keloid formation

Hypertrophic scars may be treated with intralesional corticosteroids, pulsed-dye laser, silicone gel sheeting, cryotherapy, or a combination of these methods.¹⁴ For keloids, these treatments may be combined with surgical excision, intralesional 5-fluorouracil, intralesional interferon, external compression, or a combination of these methods.^{14–17}

Nerve, tendon, or ligament damage

Paresthesia may occur at the incision site; this should improve with time. Motor nerve damage is extremely rare. A severed tendon or ligament requires referral to the appropriate specialties for evaluation and repair. The risk of this occurring is mitigated by remaining at the appropriate depth during the incision of the lesion. Consider the size and depth of lesion, anatomic location, and length of the sharp utilized as an incising instrument prior to performing the procedure, and a thorough understanding of local anatomy is of vital importance.

CONCLUSIONS

When properly performed, I&D is a useful treatment for abscesses, cysts, hematomas, and numerous other conditions. While these procedures are straightforward and can be performed with great rapidity, a poorly performed I&D procedure may serve only to exacerbate an already unpleasant or even dangerous condition. Therefore, a deep respect for anatomy, as well as an understanding of the appropriate indications and contraindications for this approach, remains of vital importance.

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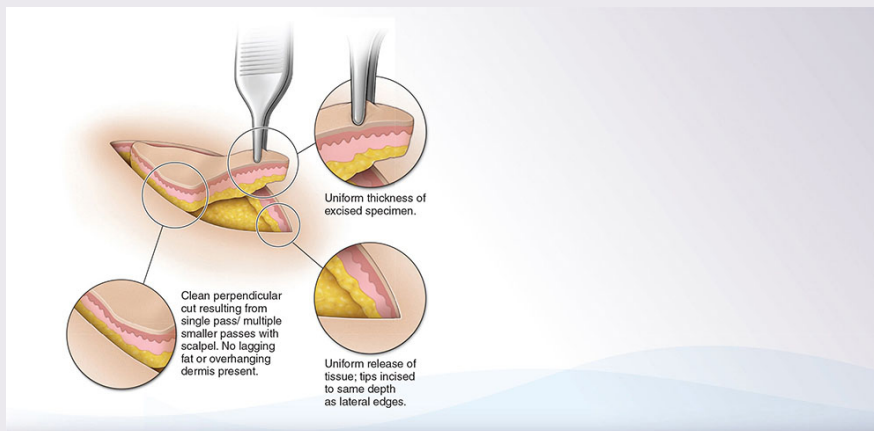
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CHAPTER 18 Layered Excisions and Surgical Repairs

Jonathan Kantor



SUMMARY

- Linear closures involve direct side-to-side closure of the surgical wound.
- Layered linear closure remains the gold standard for wound closure given its predictable outcomes, reasonable cost to the patient and healthcare system, and low risk of complications.

- Even very large defects, including those on the face, can often be closed in a linear fashion, as long as aggressive undermining and dog-ear correction are performed.
- A significant advantage of linear closures is their predictability; since outstanding blood flow is maintained to the wound edge, these closures often result in fine-line nearly imperceptible scars when carefully designed and executed.

Beginner Pearls



- Breaking down the excision and linear repair into its component parts helps conceptualize each requisite step.
- Never attempt to rush a step; most shortcuts result in the need for a far more time-consuming correction.

Expert Pearls



- Large defects on the face do not necessarily require flap repair.
- Linear closures have almost no risk of flap loss, and so are particularly useful approaches for closures in tobacco users.

- Using a rhombus or tangent-to-circle closure approach may result in smaller apical angles and less dog-ear formation.

Don't Forget!



- When deciding between a large linear closure and a flap, keep in mind that linear closures have less of a tendency to “burn bridges” for future repairs, an important consideration in the patient with florid skin cancers.
- If a wound closed with buried sutures alone results in significant gaping or overhanging dermis, do not attempt to solve this with superficial suture placement. Instead, remove the excess dermis and/or replace the deep sutures.

Pitfalls and Cautions



- Always carefully identify the source of any oozing and address it directly; judicious use of electrosurgical approaches will help reduce the amount of necrotic tissue left in a wound.
- Gentle tissue handling will result in improved outcomes, decreasing the risk of necrosis and infection.

Patient Education Points



- Explaining that any additional scar length will likely heal with a minimally visible line may go a long way toward patient reassurance.
- Always review the planned degree of eversion with the patient so that there is no confusion or worry in the immediate postoperative period regarding the ridged appearance of the wound.

Billing Pearls



- As a general rule, extensive undermining, dog-ear correction, or other complex steps are needed to bill for a complex closure.
- No amount of undermining shifts a linear excision and repair to a bilateral advancement flap for billing purposes.

CHAPTER 18 Layered Excisions and Surgical Repairs

INTRODUCTION

Direct linear closure of surgical wounds is the primary technique used for defect closure in dermatologic surgery. Linear closure is favored for several reasons, including its ease of execution; reliable and predictable healing pattern; rapidity; and reproducibility. Much of the dermatologic surgery literature has historically focused on novel flap and graft techniques, though recently a renaissance in linear closure design has occurred. Even large or deep defects on the face may be amenable to linear repairs, and indeed this may represent the best option for many such wounds.¹⁻⁷ When feasible, layered linear closure remains the gold standard for wound closure given the predictable outcomes, reasonable cost to the patient and healthcare system, and low risk of complications. Fundamental linear closure techniques, including undermining, hemostasis, tissue handling, and suture placement, represent the bedrock of all surgical closures, from small punch biopsies to large flaps.

NOMENCLATURE

The term “elliptical excision” has been used historically to denote linear wound closures, though numerous authors have, over the years, pointed out that the basic shape used by most dermatologic surgeons for closure design is not, in fact, an ellipse (Fig. 18-1).⁸⁻¹² The term “fusiform excision” has,

therefore, been proposed as an alternative, though it has yet to be universally adopted.

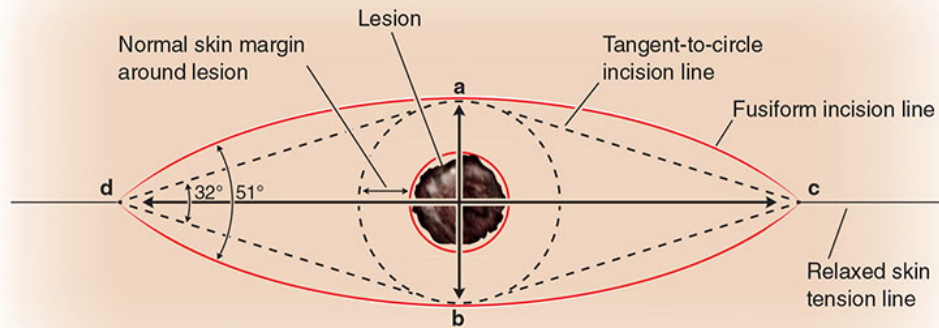


Figure 18-1. The rhombus (tangent to circle) closure inscribed within a fusiform design using a theoretical length-to-width ratio of 3.5:1.

The rhombus, or tangent-to-circle, design is a geometrically efficient approach to linear wound closure. Note that *rhomboid*, however, does not mean rhombus-like, but rather refers a specific geometric shape defined by Euclid as a parallelogram where adjacent sides are of unequal lengths. Therefore, these closures should not, from a Euclidean perspective, be referred to as rhomboid.

Most linear excisions are closed in a layered fashion, with repair of the dermis and/or fascia preceding epidermal approximation. Surgeons may refer to an *intermediate* closure and *complex* closure; these terms relate to the *billing* of closures using CPT code series. As a general rule, extensive undermining, dog-ear correction, or other ostensibly complex steps are needed to bill for a complex closure.

Some surgeons refer to undermined *flaps* of tissue that are *advanced* into the center of a wound in order to close a linear excision. While it is technically appropriate to refer to undermined sections of tissue as skin flaps, no degree of undermining shifts a linear excision and repair to a bilateral advancement flap for billing purposes, as the latter requires a true adjacent tissue transfer (for a detailed discussion of flap dynamics and advancement flaps, see [Chapters 20](#) and [21](#), respectively; for a discussion of billing, see [Chapter 10](#)).

PREOPERATIVE EVALUATION

The preoperative consultation for most linear excisions and closures can safely take place on the day of surgery, and includes a detailed medical and social history, with particular attention to the use of medications or supplements that may affect bleeding as well as tobacco use, which has a marked effect on the postoperative healing process. The details of the preoperative evaluation in general are addressed in [Chapter 3](#).

Patients should understand that there is always more than one way to skin a cat; all surgical procedures present risk, and all surgical procedures have alternatives—including avoiding surgery altogether. It is the balance of risk and benefit that must be addressed with each patient individually.

This individualized approach to patient consent and education should extend to the preoperative evaluation of the planned procedure as well. Thus, the planned surgical site should be carefully assessed visually, palpated, and the range of motion of the planned surgical site and surrounding tissues should be closely assessed. For example, when designing facial repairs the surgeon should sequentially have the patient move through the entire range of motion (frown, smile, grimace) in order to better gauge the relaxed skin tension lines (RSTLs) and the presence of any underlying fibrous attachments. In recent years, there has been a better understanding of the retaining ligaments in the cheek and beyond, which may have a significant impact on tissue mobility, particularly during larger repairs.¹³

On the hands, patients should similarly move through flexion and extension, and should be asked to make a fist. Querying the patients regarding occupational and leisure activities may also be particularly helpful, as a dorsal hand repair on a masseuse may be approached differently to that on a professional golfer. The potential for range-of-motion variation is also seen on the upper back, where baseline patient posture may affect the planned closure vector.

Linear closures near free margins should be carefully planned and assessed, and patients should understand potential risks, such as ectropion or eclabium, before the procedure is started. When assessing the potential for ectropion, the patient may be asked to gaze upward with their mouth wide open while in a semi-reclined position in order to better assess the potential for ectropion development.

As part of the informed consent process, the patient should understand that there will be a scar every time the skin is cut. The goal is not to avoid scarring altogether, which is impossible regardless of surgeon or surgical technique; it is to create the least cosmetically obvious scar while definitively treating the underlying disease process. The assessment of scar quality has been the focus of renewed interest of late, particularly as this may be used as an outcome measure for quality-of-care assessments. The SCAR scale (Scar Cosmesis Assessment and Rating scale) is a recently developed validated scale that may be particularly helpful when determining the quality of postoperative scarring.^{14,15}

The informed consent and consultation process, while unique to each patient's circumstances, should always move through the same steps. Thus all patients are handed a mirror and asked to confirm the surgery site prior to marking, and then again asked to confirm the site verbally once the site has been marked. This approach is invaluable in engaging the patient as partner regarding biopsy-site identification, and may help limit potential liability exposure in cases where wrong site surgery is alleged. In cases where the biopsy-site location is equivocal, surgery should be delayed, and consultation should be undertaken with the referring physician (if applicable), or a small scouting biopsy may be performed.^{16,17}

Prior to beginning the surgical procedure, the patient should be informed of the postoperative healing course. This includes a detailed explanation regarding limitations on physical activity, as well as an explanation regarding postoperative wound care. Furthermore, most patients (and many physicians) are not aware of the need to hyper-evert the wound edges postoperatively, and explaining that this is analogous to a subcutaneous splint that is present only temporarily until buried suture absorption is complete may be very helpful.¹⁸

LINEAR CLOSURE DESIGN AND GEOMETRY

The apical angle: fusiform and rhombus closures

Classic descriptions of linear closure designs have highlighted the role of the apical angle as a determinant of dog-ear formation. The dogma of the 3:1 (or, more recently, 4:1) ellipse with 30-degree apical angles requires significant

revision, particularly as geometrically, even a 3:1 fusiform closure mathematically cannot yield 30-degree apical angles.^{9,10,19}

Angulated (also known as tangent-to-circle and rhombus) closure designs, already advocated by Bennett in the 1980s, have also become more popular, as they permit narrow apical angles (in the neighborhood of 30 degrees) coupled with a relatively modest length:width ratio of approximately 3:1. Indeed, a 3:1 fusiform design results in a 74-degree apical angle, while a similar length-to-width ratio designed as a rhombus yields apical angles of only 37 degrees.

Another modification that blends the benefits of the rhombus design (narrower apical angles coupled with a shorter overall incision length) and the fusiform design (a gradual curving shape that is more amenable to closure without residual central gaping) is the inside rhombus-outside fusiform technique. Here, a rhombus design is first created and incised to the superficial dermis. At that point, lateral pressure on the incision (a technique that is useful in general to avoid overhanging dermis, as noted below) is used to turn the outside edges of the excision site into a fusiform shape while allowing the excised segment of skin to remain as a rhombus, albeit with overhanging dermis on its midsection (Figs. 18-2 and 18-3).



Figure 18-2. The inside rhombus-outside fusiform technique involves incising a rhombus shape initially and then aggressively pressing outward with the blade during subsequent passes.



Figure 18-3. This leads to a defect that is shaped like a rhombus with narrow apical angles but a wound contour that appears more fusiform.

TOPOGRAPHY

The three-dimensional topography of the wound should also be considered when designing a linear closure.¹¹ Indeed, restoring—or maintaining—the natural contours may be at least as important as repairing a wound with a thin scar.^{20,21} For wounds over convex surfaces, designing a straight-line fusiform closure may lead to both short- and long-term undesirable outcomes. In the short term, dog-ear formation may be exaggerated over the extremes of convex surfaces, and such standing cones may not be resolved using standard dog-ear correction techniques (see [Chapter 19](#)). This is the origin of the “chasing the dog ear” phenomenon that may be seen classically when working on the forehead. In the long term, scar contraction occurs three dimensionally; when lateral scar contraction occurs over a convex surface,

this may lead to a clinically apparent depressed scar.¹¹ Several approaches may be used to mitigate this risk, including the S-plasty.^{22–25}

Cosmetic subunits

Keeping a linear closure within a cosmetic subunit, and ideally along a cosmetic subunit boundary, may help lead to an ideal scar.^{1,20} Even very large defects may be hidden very effectively as long as the suture line, however lengthy, remains along cosmetic subunit boundary lines (Figs. 18-4 through 18-6). One of the central advantages of the linear closure design is that it results in a single fine line that is often effectively hidden. Flap repairs by their very nature result in angulated scars, and even with precise suturing techniques, these scars may remain visible, with pin-cushioning a possibility as well.¹ Angulated or geometric scars, once thought to be less obvious to the observer, may actually result in inferior cosmesis, and therefore excisions performed with this goal in mind should probably best be avoided.



Figure 18-4. Moderately-sized defect after Mohs micrographic surgery for basal cell carcinoma.



Figure 18-5. Largely linear repair respecting cosmetic subunit boundaries. Note the downward push on the lip caused by central axis lengthening.



Figure 18-6. Six-month postoperative view showing a nearly undetectable scar and no residual push on the upper lip.

Tension vectors

Understanding and planning for tension vectors parallel to RSTLs and perpendicular to free margins is an important component of linear excisions and repairs. Preplanned ideal tension vectors are not uniformly reliable, even when designed by experienced dermatologic surgeons.^{26,27}

Moreover, the tension vector of the *suture line* is not necessarily the same as the tension vector of the *sutures*; since the tension vector of the sutures dictates the direction of tissue movement, this has important implications for reconstructive design (Fig. 18-7). For example, repairs on the upper cheek or near the lower orbital rim are often closed in a linear or S-plasty fashion. To conform to RSTLs, portions of the excision may lay parallel to free margins such as the lower eyelid. By maintaining the tension vector across the sutures parallel to the free margin, an ectropion-free closure may be accomplished.



Figure 18-7. Orienting the tension vector of the sutures parallel to the free margin can permit closures without free-margin distortion.

The RSTLs over extremities do not consistently conform to the angle of minimal tension under all circumstances, since range of motion has an impact on tension. For example, on the thigh, the true RSTL may be along the long axis with extension but along the transverse axis with flexion. The

anticipated range of motion for the patient should therefore be addressed, and at times utilizing the average of the two angles—the mean RSTL—may be a helpful approach.

Moreover, conforming to the RSTL is not necessary or ideal in all cases. For repairs on the forearms, the RSTL would dictate closure along the long axis of the forearm. Yet given the convex surface of the forearm, this would also increase the risk of long-term dog-ear formation with scar contraction, necessitating a longer scar length. Transverse closures on the forearms may result in cosmetically more appealing closures given the ability to minimize the excision length. Conversely, for dorsal hand closures, the RSTL may run transversely, though closures are often best aligned along the long axis to minimize the long-term risk of lymphedema.

Free margins

Free margins, such as the lips, eyelids, alar rims, and helical rims, are both more susceptible to distortion (given their lack of bony attachments) and more cosmetically obvious when distorted (given their prominence in facial cosmesis) than other areas on the face. Therefore, preserving the position of the free margins is of great importance. Free margins can be both pulled (as in a lower eyelid ectropion caused by downward pull on the lower lid) and pushed (as in an upper lip closure forcing a section of dog-ear downwards). Keep in mind the potential for central axis lengthening as a result of wound closure, as this “pushing” effect due to the differential between the length of the central axis (apex to apex) and the (longer) length of each of the outside wound edges means that postoperatively the length of the linear closure will be longer than anticipated; this may impact repairs around the lips, where tissue may be pushed leading to an immediate postoperative puffiness which often resolves spontaneously.

Evaluation

A bright light and/or Wood’s lamp is very helpful in adequately assessing clinical tumor margins. Sidelighting as well as gently rubbing the lesion with an alcohol wipe and manipulating the skin are all helpful techniques.

Surrounding skin should be evaluated as well; this serves to both ensure that there is no local inflammation that may impede wound healing (seborrheic dermatitis, angular cheilitis, etc.) and to assess whether the postexcision defect will impinge on other preexisting nevi or other skin lesions. For example, a banal nevus that was just lateral to a newly excised dysplastic nevus may appear directly adjacent to the scar line postoperatively. This should be noted and reviewed with the patient so that a focal area of pigmentation adjacent to the scar line is not confused with recurrence.

Scars elsewhere on the patient's body should be evaluated as well, if possible. This serves two purposes: first, it provides a baseline measure for the surgeon regarding the patient's propensity to heal with hypertrophic or telangiectatic scarring. Second, it provides a reference point for patient education, so that the patient may be told what to expect in terms of healing relative to their existing scars. It may also be a significant motivator for encouraging adequate postoperative compliance.

Determining excision size

Dermatologic surgeons perform linear excisions for many indications, including the treatment of nonmelanoma skin cancers, dysplastic nevi, banal or congenital nevi, cysts, and lipomas. For both melanoma and nonmelanoma skin cancer, various studies have examined appropriate surgical margins.^{28–37} See also [Chapters 46 to 48](#) regarding management of specific tumor types.

With time and experience, dermatologic surgeons may trend toward smaller excisions with tighter margins for most low-risk nonmelanoma skin cancers, though maintaining wide and deep margins for melanoma resection remains of critical importance to minimize the risk of potentially catastrophic recurrence.

Benign nevi may be excised en bloc or in segmental or staged fashion. Benign subcutaneous tumors may be excised via modestly sized access incisions and then dissected out subcutaneously to minimize the size of the postoperative scar.

LEARNING LINEAR REPAIRS

Several studies have evaluated techniques to both learn and assess surgical competency and technique.³⁸ Objectively assessing surgical skills is critical, as novice surgeons tend to significantly and consistently overestimate their competence.³⁹ Breaking down surgical excisions and repairs into their component parts, and focusing on particular quality metrics and checkpoints at each step, may be very helpful when learning these techniques.^{40,41}

Of all skills, eversion is least often performed successfully by applicants to dermatologic surgery fellowship programs, suggesting that further focus on meticulous everting suturing techniques, including the set-back suture and buried vertical mattress suture, may be of significant didactic value.^{42–44} While one study questioned the value of eversion per se as a contributor to postoperative cosmesis, it may represent a surrogate endpoint for meticulous wound-edge approximation and tension reduction.⁴⁵

OPERATIVE TECHNIQUE

The excision with linear repair may be broken down into several component parts.

Preparation

After the informed consent process and preoperative consultation are completed, the skin is prepped and infused with local anesthetic (see [Chapter 12](#)). A sterile skin prep is generally performed for dermatologic surgery excisions, though data have suggested that the use of sterile gloves for brief and straightforward procedures may not confer a reduced risk of postoperative wound infection.^{46–48} Common surgical scrubs include chlorhexidine and povidone–iodine; the former confers the advantage of rapid onset of action even while wet,⁴⁹ though chlorhexidine should be kept out of the eyes and ears due to risks of keratitis and ototoxicity, respectively.⁵⁰

Marking

Skin marking is important when preparing for linear closures; many surgeons draw a fusiform (or rhombus) shape to delineate the planned excision.

Another approach that minimizes the amount of tissue marking used is to draw only minimal markings that outline the closure vector, closure extent, and margins around the lesion to be excised (Fig. 18-8).

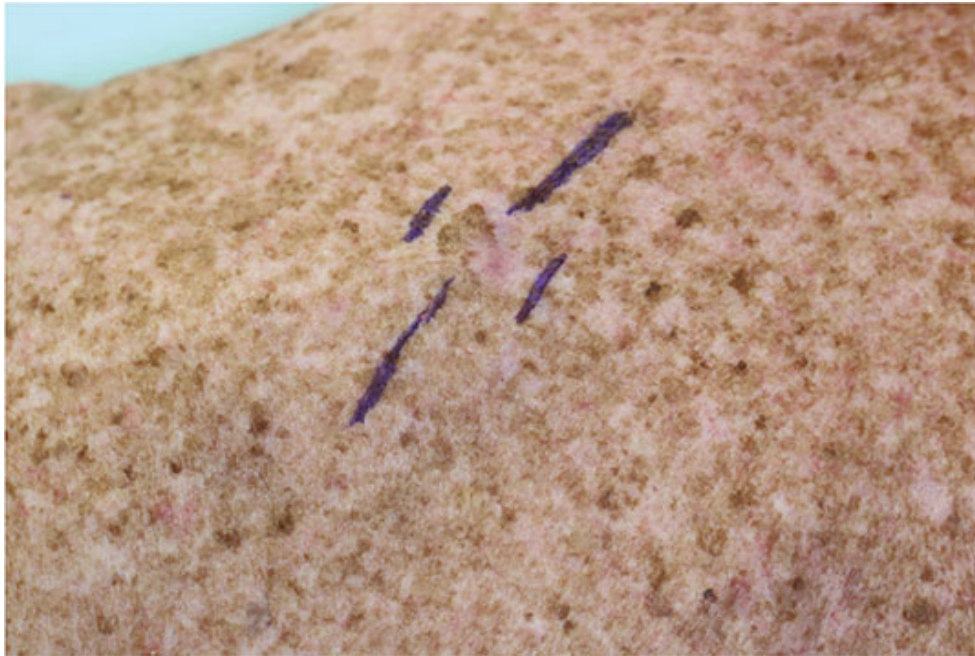


Figure 18-8. Minimal markings that outline the closure vector, closure extent, and margins around the lesion to be excised can be used. This provides key information to the assistant for local anesthesia infiltration while using a minimal amount of ink that may later need to be removed.

Regardless of the planned defect shape, it may be useful to mark additional anatomic landmarks as well. On the face, cosmetic subunit boundaries may be marked prior to local anesthetic infiltration (Fig. 18-9). On the extremities, particularly when more than one vector appears *a priori* appropriate, both vectors may be drawn out and prioritized (Fig. 18-10). Finally, when working around tattoos or near large superficial vessels, pacemaker leads, or other structures that should be avoided, these may be marked as well in a clear and consistent manner (Fig. 18-11).

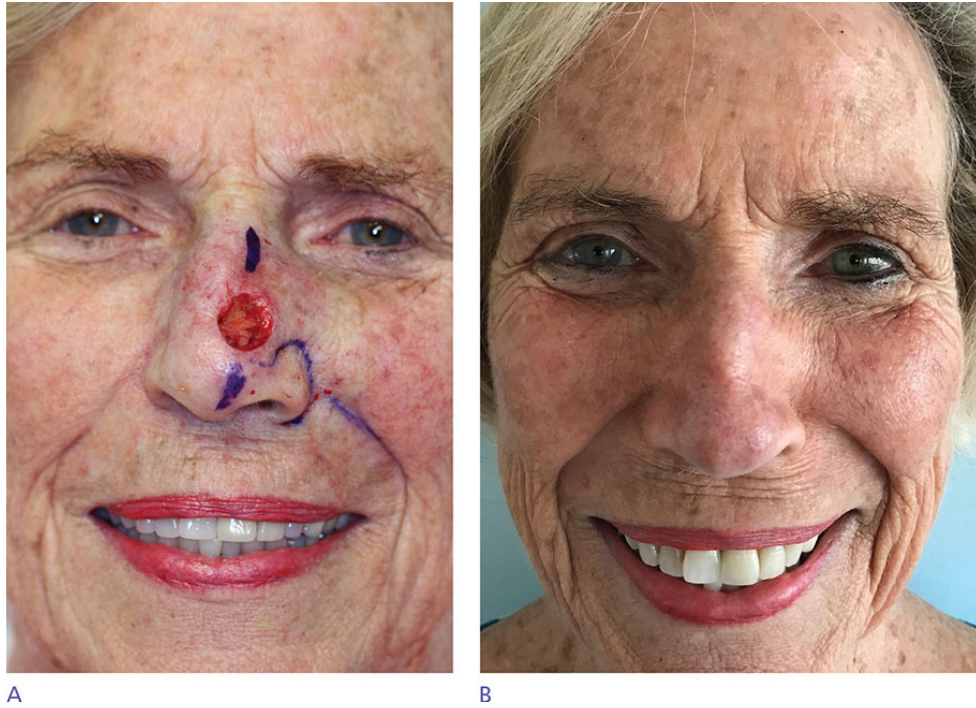


Figure 18-9. Cosmetic subunit boundaries may be marked prior to local anesthetic infiltration. **A.** Preoperative photograph. **B.** Postoperative photograph.



Figure 18-10. Multiple tension vectors may be drawn out if needed and sufficient local anesthetic may be infused to use either vector. A circular excision may be performed and the lowest tension vector can then be chosen.



Figure 18-11. Marking structures to be avoided in a clear manner is a helpful preoperative step.

Most dermatologic surgeons use felt-tipped surgical marking pens given their ease of use and low cost; patients should be told that any residual ink may be removed with alcohol. Other options include gentian violet, specialized white tissue markers, and white eyeliner markers.

Local anesthetic infiltration

Local anesthesia revolutionized the field of surgery in the late 19th century.⁵¹ Patients judge the quality of their surgeon based largely on the painlessness of the procedure and the absence of long-term scarring. Particularly given its impact on patient anxiety, adequate and comprehensive local anesthetic infiltration is a prerequisite for successful dermatologic surgery. For smaller cases, direct infiltration is effective. For larger surgical sites, a ring block, nerve block (if possible), or tumescent anesthesia may be considered. For a detailed discussion of local anesthetic infiltration, see [Chapter 12](#).

Incision

After sterile skin preparation and draping, the lesion is excised. The ideal scalpel entry angle for a fusiform excision has been classically described as 90 degrees to the skin;⁴¹ others have suggested a 10-degree outward (reverse) bevel, while more recently, it was suggested that a more dramatic reverse bevel may be desirable.^{52,53} In practice, when working on facial skin or on the forearms, true perpendicular incision angles work well; on the back, particularly in younger patients with a robust dermis, a reverse bevel may be advantageous and minimize the need for removal of any residual overhanging dermis ([Figs. 18-12 through 18-20](#)). This is particularly an issue as after the initial release of epidermis and superficial dermis there is a tendency for the outside (nonincised) edges of the excision to spring laterally ([Fig. 18-21](#)).⁴¹ Stabilizing the surrounding skin during scalpel entry and during incision creation may help maintain a consistent angle.



Figure 18-12. An incision is made along the marked axis with the blade held perpendicular to the skin or with a slight outward bevel.



Figure 18-13. The incision is made to a uniform depth including the apices.



Figure 18-14. The specimen is incised at a uniform depth on its undersurface.



Figure 18-15. Sharp undermining is performed with surgical scissors or a scalpel.



Figure 18-16. The apices are undermined extensively.

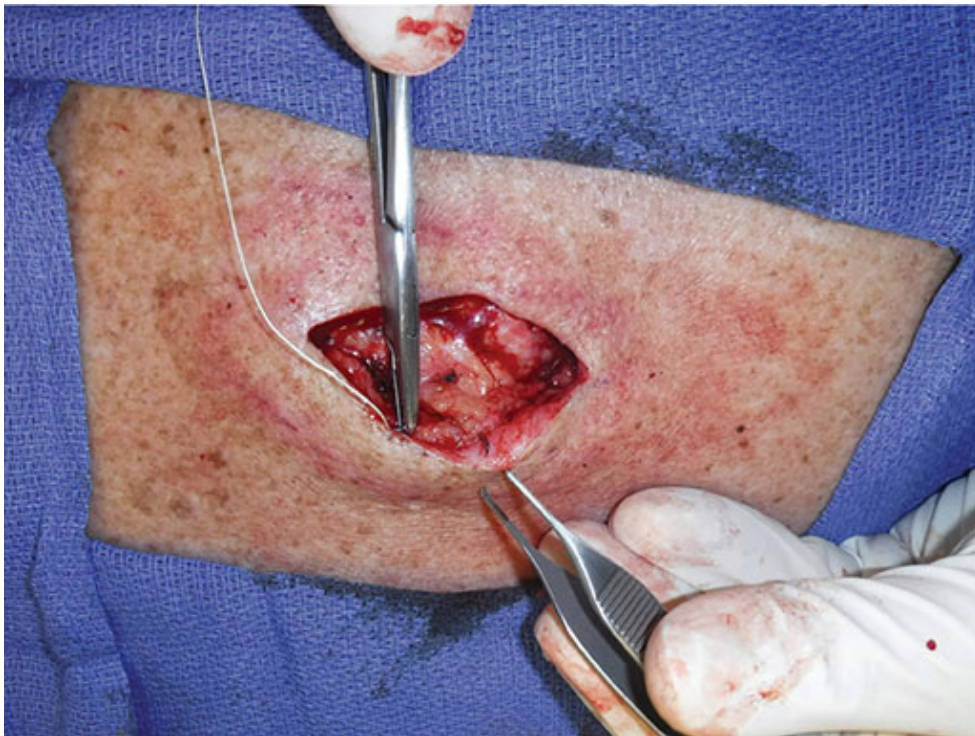


Figure 18-17. A fascial plication suture is placed to reduce tension and decrease the apical angle further.



Figure 18-18. Tightening this suture leads to narrower apical angles.



Figure 18-19. After a single fascial plication suture is placed, the bulk of the wound is closed and tension is reduced.



Figure 18-20. Set-back or buried vertical mattress sutures are then placed, allowing the wound edges to drape together under minimal tension.



Figure 18-21. After incising and tissue release, there is a tendency for the lateral edges of the wound to spring back from the central defect.

Most standard descriptions call for the tip of the scalpel to be used initially, followed by the belly of the blade which is ostensibly sharper than the tip. While common surgical folklore, this is more critical when using the larger #10 blade than when using the #15 blade that is typically used in dermatologic surgery. Similarly, references to holding the surgical blade like a violin bow are largely a result of translating general surgery techniques to

dermatologic surgery. The violin bow technique is classically described when using a #10 blade, which is significantly larger than the #15 blade. Similarly, some textbooks historically advocated that a single pass of the scalpel should incise through epidermis, dermis, and through to the subcutaneous fat; in practice, this is both unnecessary and difficult to achieve unless excessive force is used. Therefore, the surgical blade may be held like a pencil and careful and consistent traction may be used to permit a smooth incision through the dermis, though multiple passes, particularly when working on the back, are perfectly acceptable.

Tissue release

Uniform excision and tissue release are very helpful in elegantly excising tissue and preparing the nascent wound for reconstruction. The tendency to bevel the excision inward at the apices may result in the rowboat deformity, which increases the risk of dog-ear formation unless the excess tissue is separately removed prior to reconstruction. Therefore, excision to a uniform depth and with a uniform angle is desirable. A well-planned excision saves significant reconstructive time by obviating the need to trim overhanging dermis prior to wound closure.

Some authors have referred to the “lagging fat” phenomenon, where the epidermis and dermis tend to retract away from the center of the wound after tissue release, but deep fat—without lateral fibrous attachments—lags centrally and presents a physical impediment to wound closure.⁴¹ In clinical practice, there is often a significant lagging *dermis* phenomenon, where even with a 90-degree perpendicular incision a significant amount of reticular dermis may protrude centrally, particularly in areas with a more robust dermis such as the back. This may be obviated by either excising tissue with a reverse bevel or, after the fact, by trimming the lagging dermis (Fig. 18-22). Importantly, no degree of suturing technique-based correction can solve this physical problem definitively, and investing a few moments in assuring that the wound edges are uniform prior to closure is time well spent.



Figure 18-22. Trimming any lagging dermis a critical step that must always take place if dermis is present medial to the epidermal edge.

Undermining

Undermining serves several purposes. First, it permits closure of large (based on defect size) or tight (based on lack of elasticity, such as on the scalp and lower leg) defects under tension that would otherwise not close easily. Second, it reduces tension across moderately tense defects by recruiting adjacent skin for the closure. Third, it frees up underlying attachments that would otherwise lead to both lateral and downward pull, potentially leading to wound inversion.

It is important to undermine the apices as well as the lateral portions of the wound.¹¹ In fact, wide apical undermining may in some cases be *more* important than lateral undermining given its potential to partially mitigate dog-ear formation.

Disadvantages of undermining include its potential impact on blood supply, as wide undermining essentially creates a small local random pattern flap.⁵⁴ Undermining also increases intraoperative morbidity, by creating a potential space for hematoma or seroma formation.

The plane of undermining has a profound effect on surgical outcomes, as it may affect the risk of bleeding (and the resulting need for more aggressive and time-consuming hemostatic measures), as well as the risk of nerve damage. Remaining in a uniform plane is important, and may be aided by retracting back the skin with uniform pressure.

Novice dermatologic surgeons often prefer to err on the side of remaining superficial, and have a tendency to attempt all undermining at the level of the superficial fat, fearing an increased risk of bleeding or nerve compromise with deeper undermining. Understanding the vascular supply of various anatomic areas may be helpful, as overly superficial undermining may also increase the risk of damage to perforating vessels supplying the dermal plexus, decreasing vascular supply and increasing the risk of necrosis. Deeper undermining may permit the reapproximation of deeper, well-vascularized structures rather than only the relatively thin dermis and epidermis. This phenomenon may be seen when performing a linear closure on the nose, where deep submuscular undermining affords a robust vascular supply to the advancing wound edge, while superficial subdermal undermining leads to a significant risk of postoperative necrosis.

When undermining, keep in mind that a scalpel and scissors work from opposite directions: the scalpel cuts from the distal point to the more proximal point, while scissors begin cutting proximally and extend the incision distally.

One recent study evaluated the relative merits of wide undermining and imbrication.⁵⁴ In this porcine study, both undermining and imbrication were studied to assess their effect on wound tension and perfusion. Not surprisingly, both techniques led to decreased tension across the surface of the wound, and both led to a marginal drop in wound perfusion, though imbrication was associated with a slightly more dramatic decrease in perfusion. Notably, the experimental wounds were undermined a full 4 cm, significantly beyond the point that most surgical wounds are undermined in dermatologic surgery.

When feasible, undermining should be minimized in patients on thrombolytic agents such as aspirin or in those with very ruddy skin who are prone to numerous small wound-edge bleeding vessels.

Pragmatically, undermining is best performed under direct visualization. Sharp dissection may lead to less tissue trauma as it avoids shearing forces that may be seen with blunt or spread undermining. While many surgeons

prefer blunt-tipped surgical scissors, such as blepharoplasty scissors (for almost all cases) or Metzenbaum, facelift, or Mayo scissors (for larger cases), on a practical level sharp undermining may also be performed with a scalpel, or using electrocautery on either a pure-cut or blend setting. Radiofrequency cutting devices, as well as newer cold plasma devices, may also be used. These confer the advantages of reduced thermal injury though they are also associated with a significantly increased cost that makes them impractical for most linear excisions and repairs.

Hemostasis

Achieving adequate hemostasis prior to wound closure is an absolute requirement. Experience is very helpful in distinguishing between low-level wound-edge oozing that may resolve with suturing and pressure, and true bleeding that should be addressed with aggressive hemostatic measures. There is a delicate balance between mitigating the risk of hematoma formation and overly desiccating wound edges that may impair healing over the long and short terms. Larger vessels should be clamped and ligated, rather than treated with electrosurgical approaches, in order to minimize the risk of bleeding in the acute postoperative period. Bipolar forceps may be useful, though they are not necessary.

Bleeding should always be addressed under direct visualization, and skin hooks—usually used as a pair to tent up the overlying epidermis and dermis—may be very helpful for this purpose.

Suturing

Suturing techniques affect the efficiency of surgical reconstruction, and suturing technique choice may also impact overall linear closure design. A detailed discussion of suturing techniques and their variations may be found in [Chapter 13](#).

Historically, most linear closures relied on a bilayered closure approach, with sutures placed in the dermis for tension relief and transepidermally for wound-edge approximation. This paradigm has shifted over the past few years, with the realization that recruiting deeper tissue planes may have a profound effect on wound strength and cosmesis.^{55,56}

Fascial plication is one of the most useful techniques for linear closures, as it confers several advantages simultaneously.⁵⁵ First, it leads to significant tension reduction over the wound surface by shifting tension to the deep fascia. Second, it decreases the amount of undermining needed to permit effective closure, theoretically improving vascular supply to the undersurface of the advancing wound edges and reducing the risk of potential space formation that may increase the risk of hematoma formation. Finally, fascial plication has a significant effect on wound geometry, as a single fascial plication suture shifts a wound from a 3:1 fusiform shape to a 6:1 ratio and decreases the apical angles significantly.⁵⁵

Fascial plication sutures need not be used for all linear closures. This technique is most appropriate for areas under significant tension, or large excisions where minimizing the postoperative wound length is desirable. On the face, recruiting the SMAS may be very helpful. When designing the closure of a round defect, the fascial plication suture should be placed prior to removing the dog ears. The risks of fascial plication sutures include possible pain, a theoretically increased infection risk (since the fascial envelope has been pierced by suture), and a theoretical risk of vascular compromise through inadvertent pressure-induced ligation of perforating vessels. In practice, these complications are infrequent, though patients may experience transient pain during needle entry and immediately after the fascial plication suture is tied. If pain persists for more than 5 minutes, the suture should be removed.

Buried dermal sutures are the cornerstone of linear repairs. Two central suturing techniques are useful: the buried vertical mattress suture and the set-back dermal suture. The former yields significant wound-edge eversion and epidermal approximation, while the latter is easier to execute. A randomized controlled trial has suggested that the set-back suture leads to cosmetically more appealing scarring than the buried vertical mattress suture.⁴² Its ease of use is a significant advantage as well, particularly as effective wound-edge eversion is one of the most challenging (and clinically critical) components of the linear excision and closure.³⁸

Set-back dermal sutures result in marked wound-edge eversion, though this can be adjusted based on how far each set-back bite is taken from the incised wound edge. For a detailed discussion of step-by-step suture placement, see [Chapter 13](#).

Though many manuscripts and chapters addressing linear closures advocate the placement of a key suture in the center of the wound followed by closure using the rule of halves, in practice this may be less desirable than starting at one edge of the wound—typically the edge most distant from the surgeon—and moving proximally. The latter technique allows tension to be gradually relieved, minimizing the tension across any single suture. This permits tissue creep to gradually take place over the course of the closure.

The set-back or buried vertical mattress sutures may be placed closer together in the center of the wound, where tensile forces are the greatest. After placement of a full row of buried sutures, the wound edges should be well everted, and ideally drape together under no tension. With assiduous attention to detail, this layer of sutures may lead to ideal wound-edge approximation, obviating the need for transepidermal sutures.

If transepidermal sutures are placed, they may be performed in a simple interrupted or running fashion. Ideally, there should be no tension across the wound surface after deep suture placement, and therefore running sutures may be appropriate. Alternatively, some mild depth correction may be needed and in such cases depth-correcting simple interrupted suture can be used. Running horizontal mattress sutures, often with intermittent simple loops, may also be helpful for yielding excellent wound eversion and avoiding suture material crossing over the incised wound edge.^{57,58} Running subcuticular sutures may be used as well, though in the context of well-placed buried sutures, they often confer only minimal advantage while introducing additional foreign body material across the wound.

Most dermatologic surgeons use reverse-cutting needles; these confer several advantages, and may theoretically decrease the risk of suture material tear-through since the cut edges are on the opposite sides of the vector of maximal postoperative tension.

VARIATIONS

S-plasty

The S-plasty variation of the linear repair is useful for closures over convex surfaces. Given the tendency for linear closures to contract during wound healing, straight-line repairs may lead to scar contraction over convexities

that is particularly visible as scar maturation occurs. By lengthening the overall scar length—and particularly extending the scar length over the convexities—the S-plasty may result in better long-term cosmesis for these repairs.

Some authors have advocated the S-plasty as a technique for all closures, arguing that the extended scar leading to decreased lateral contraction may ultimately provide a superior cosmetic result even in the absence of a convexity.⁵⁹ This theoretical benefit should be weighed against the desire for a straight-line linear repair. Some variations of the S-plasty use shortened or differentially angled arms to reduce the overall incision length, or rely on suturing techniques to add curvature to an otherwise linear repair.¹⁰

When orienting the S-plasty, the curved tips of the repair should follow the RSTLs as much as possible. All S-plasty repairs should be conceptually repaired using the rule of halves, which in practice requires that all sutures are placed perpendicular to the excision (Figs. 18-23 through 18-26). If this is not done, a defect incised as an S-plasty may ultimately appear as a longer straight line.



Figure 18-23. An S-plasty may be used when working over a convex surface, such as the forearm.



Figure 18-24. The S-plasty incision is made to a uniform depth.



Figure 18-25. The excision is performed leaving an elongated S-shaped defect.



Figure 18-26. A fascial plication suture may be used to reduce tension and increase the apical angles.

Eccentric parallelogram

The eccentric parallelogram has been advocated as an alternative to both the fusiform and rhombus repair.¹⁰ This approach provides some geometrical advantages, though like the S-plasty it results in a curved final scar. A variation of the eccentric parallelogram may also be performed using a triangle–square–triangle technique that may result in a straight-line closure.

Crescentic excisions and sides of unequal length

Since a goal of all surgical repairs is to hide the postoperative scar as effectively as possible, some scars may be purposely curved for optimal cosmesis, such as those in the nasolabial and melolabial folds. When designing a crescentic excision, the curved side will dictate the final angle of the repair as long as suturing is performed using the rule of halves.

Occasionally, a defect will be created with two sides of unequal length. This may occur in the context of a linear closure, after attempting to repair a dog ear, or from the secondary defect (or shifted standing cone) of a flap repair. Specialized suturing techniques have also been proposed for repairing wounds with unequal side lengths (Fig. 18-27).

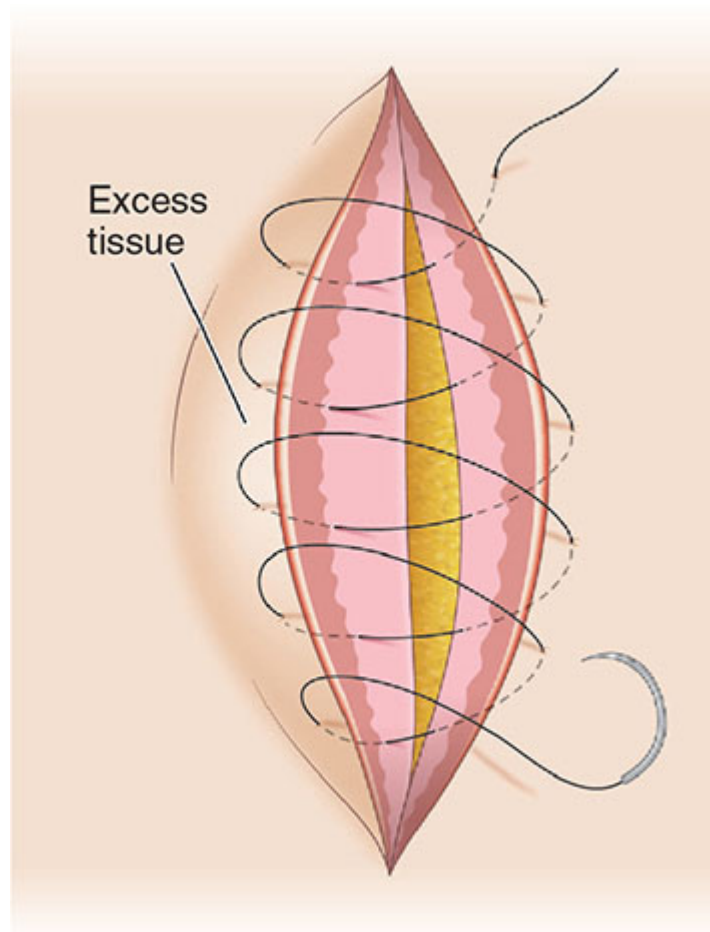


Figure 18-27. The running pleated suture is sometimes used when repairing wounds with unequal side lengths, though following the rule of halves is often a more straightforward approach.

Circular defect with dog-ear repair

Not all linear closures must begin as fusiform or rhombus shapes. Indeed, several studies have suggested that the round excision with ensuing dog-ear correction may yield a shorter postoperative scar than primarily designed fusiform closure. An additional advantage of this freestyle technique is that the ideal closure vector can be determined once the central defect has been created, a significant advantage as even experienced dermatologic surgeons do not consistently select the ideal closure vector.^{26,27,60}

This approach is particularly useful when performing a large excision, where the ideal vector of tissue closure is not *a priori* obvious. This approach also provides an easily oriented specimen for the laboratory. The excision is performed to conform to the native margins of the lesion being excised. It is carried to the appropriate depth, and a perpendicular incision is made circumferentially to minimize the risk of residual overhanging dermis. Once the excision is completed and the specimen is appropriately tagged, wide undermining may be performed and the different potential angles for closure are explored. A fascial plication suture along the appropriate axis may be useful prior to contemplating dog-ear removal, as this may limit the amount of additional tissue that needs to be excised. After dog-ear removal, the wound is then closed in a layered linear fashion.

A detailed discussion of dog-ear repair techniques may be found in [Chapter 19](#).

Delayed dog-ear repair

The tendency toward standing cone formation at the apices of a linear excision is a function of (a) tissue bunching and redundancy; (b) wound edema; and (c) a more pronounced central depression. As two of the three causes of immediate dog-ear appearance are only temporary, it may be preferable to err on the side of taking a smaller dog ear at the time of closure. This must be weighed against patient concerns in the immediate postoperative period regarding the appearance of the nascent dog ears, as some patients are less concerned regarding postoperative cosmesis and would prefer to have a shorter scar. Additionally, especially in areas such as

the lower leg that are at high risk of dehiscence, creating the smallest possible wound is a clear advantage.

M-plasty

M-plasty can be conceptualized as a small V-Y closure at one pole of an otherwise linear repair, and is useful for reducing the length of a linear closure. This approach is classically used around the eyelids, where the M-plasty may be hidden along the rhytides, though it can be used in any situation where a standard dog-ear repair would approach free margins or adjacent cosmetic subunits. The net result of M-plasty formation is that the dog-ear length is reduced by approximately 1/2. For a detailed discussion of dog-ear repair techniques, see [Chapter 19](#).

Nonundermined repairs

While undermining is a standard technique to facilitate both lateral tissue movement and permit the placement of deeper buried sutures (such as the set-back suture), it is neither necessary nor appropriate in all situations. As noted above, undermining itself leads to some vascular compromise as has been demonstrated in a porcine model.

Markedly atrophic skin should almost never be undermined. This is not due to concern regarding skin tear or skiving, but rather because with atrophic skin, the underlying fibrous attachments between the underside of the dermis and the deeper subcutaneous tissues provide the greatest purchase for buried sutures. A modified simple buried dermal suture is used in these cases, taking as large a bite as possible on each side, beginning on the undersurface of the deep subcutaneous tissue or even underlying fascia. Avoiding undermining may permit such wounds to be closed easily without resorting to adjuvant approaches such as suturing through tissue adhesive bolsters.^{61,62}

Second, wounds in areas of very poor baseline perfusion, such as the lower legs, may sometimes be repaired without undermining. This serves two purposes: first, it obviates the risk of perfusion reduction secondary to undermining proper, and second, it creates a smaller subdermal defect in the event of dehiscence.

Partial closure

Partial wound closure may be considered in areas where there is extreme wound tension across the central portion of the defect, such as those on the scalp and lower leg. In such cases, the poles of the wound may be approximated in a linear fashion, but a central area of wound gaping may remain. One option for these repairs is via a Burow's graft, taken from one of the poles of the wounds (see [Chapter 28](#) for a detailed discussion of skin grafts), though permitting this small area to heal by secondary intention is appropriate as well. Adequate patient preparation is of course a prerequisite to this approach.

Another technique for partial closure is used when extreme tension across a wound does not permit direct side-to-side wound apposition at all.⁶³ While traditionally other repairs would be entertained, in select patients, partial linear closure allowing the remainder of the wound to heal by secondary intention may be appropriate. This can be conceptualized as a strategy to reduce the size of the defect that will heal by secondary intention. Such repairs may also be performed prior to skin graft placement.

At times, portions of an otherwise linear repair may be purposely left to heal by secondary intention. For example, when recreating the alar groove, the deepest part of the groove may be left to heal secondarily (or grafted) as an alternative to inverting suture placement.

Staged (serial) excision

When excising a large benign lesion, such as a congenital nevus, staged excisions may permit wound closure with a smaller ultimate repair size than would be needed otherwise. This approach combines several fundamental principles, including tissue creep, tissue stretch, and the ability to perform all but the final stage of the repair as purse-string closures to minimize the final scar length. Other approaches, including a torus (doughnut) approach to staged excisions, as well as a compressed design method using an X-shaped repair, have been described as well.⁶⁴

Multidirectional vector excision

The multidirectional vector excision was proposed as a single-stage alternative to the staged excision for the removal of benign lesions. With this technique, multiple small triangular shaped sections of the benign lesion are pulled with skin hooks in order to determine the optimal closure vector.⁶⁵ Future investigation is needed regarding this niche technique.

Special considerations for post-Mohs repairs

Repairing a defect after Mohs surgery may be conceptualized similarly to the circular defect approach. In addition to wide undermining and the determination of optimal dog-ear removal angles, post-Mohs surgery repairs also should often be debeveled prior to closure. Moreover, sometimes the post-Mohs defect should be deepened prior to closure in order to ensure that closure takes place in the optimal tissue plane.

SPECIAL ANATOMICAL CONSIDERATIONS

Eyelids

Linear repairs on the upper eyelids may be performed as long as significant postoperative asymmetry is not anticipated. If this occurs, a modified blepharoplasty on the contralateral lid may be performed to restore symmetry. On the lower eyelid, excisions may be designed parallel to the lower lid as long as the tension vector across the sutures is perpendicular to this axis (Figs. 18-28 through 18-32). If needed, a stress maneuver with open-mouth and upward gaze should be performed prior to closure design. Keep in mind that Frost sutures (Fig. 18-33) do not mitigate the risk of ectropion due to poorly designed repairs; they simply prevent this occurrence secondary to edema in the immediate postoperative period. For a detailed discussion of eyelid repairs, see [Chapter 38](#).



Figure 18-28. A defect near the eyelids can be closed in a linear fashion as long as tension vectors are considered.



Figure 18-29. The first suture is placed with the goal of maintaining tension vectors parallel to the free margin.



Figure 18-30. The second half of the suture is placed.



Figure 18-31. Note that the suture material is oriented horizontally so that there will be no vertical pull on the lower eyelid, reducing the risk of ectropion.



Figure 18-32. The wound is shown after the placement of an additional buried suture. Note the wound eversion without any evidence of ectropion.

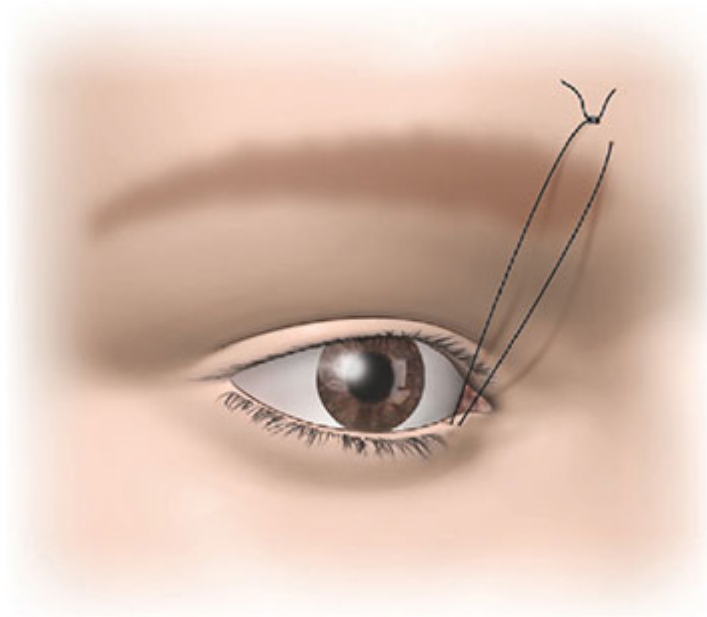


Figure 18-33. A Frost suture may be used to minimize ectropion secondary to postoperative edema in an otherwise well-designed repair.

Nose

Linear repairs on the nose are possible even for fairly large defects, particularly those located in the midline.¹ This approach is predicated on a high length-to-width ratio closure in order to avoid the risk of dog-ear formation at the apices, which is particularly noticeable on the nose. The depth of the excision and suture placement should be significant, as superficially placed sutures and superficial undermining on the nose increase the risk of dehiscence. Buried sutures should ideally include nasalis muscle in order to provide optimal cosmesis.

Patients should be warned that all nasal repairs should be conceptualized as multistaged, given the sebaceous nature of nasal skin. Postoperative dermabrasion is often useful, and if patients are told preprocedure that this may be needed, they will be more satisfied with the ultimate outcome. For a detailed discussion of nasal repairs, see [Chapter 39](#).

Lips

Linear repairs on the lips often heal very well, as long as the white line and wet line are appropriately prioritized. Deep defects should be repaired in a layered fashion, including repair of the orbicularis oris. While silk sutures have traditionally been advocated for the outer layer of lip closures, braided absorbable suture, such as polyglactin 910, is also very soft and may permit layered closure with a single suture packet. For a detailed discussion of lip repairs, see [Chapter 40](#).

Ears

Linear repairs on the ear are often possible and provide outstanding cosmesis. When orienting a repair along the helix, a high length-to-width ratio is helpful in maintaining the natural curvature of the ear. Percutaneous sutures may be helpful (see [Chapter 13](#)) when working with atrophic skin. For a detailed discussion of ear repairs, see [Chapter 41](#).

Cheeks

The cheeks are subject to significant tensile stress and often include significant convex components. Therefore, both S-plasty and crescentic

approaches may be useful. Even large defects on the cheeks can often be closed in a linear fashion (Figs. 18-34 through 18-36). Patients should go through their full range of facial movement before deciding on an optimal tissue vector. Occasionally, M-plasty may be useful when approaching free margins. Fascial plication and set-back sutures are useful for maintaining well-everted wound edges under minimal tension. For a detailed discussion of cheek repairs, see [Chapter 42](#).



Figure 18-34. Lentigo maligna on the cheek can be easily closed in a linear fashion.



Figure 18-35. Wound appearance immediately after SMAS plication and buried suture placement. Note the presence of overhanging dermis that will be removed prior to the completion of the repair.



Figure 18-36. At 6-month follow-up, the wound has healed with barely visible scarring.

Forehead

The forehead is usually repaired in a linear fashion, though closure vectors are of particular importance given the potential impact of repairs on eyebrow positioning. Many small forehead defects are repaired along the rhytides in a transverse fashion, and small defects often result in only temporary eyebrow elevation. Large repairs are best performed in a layered vertical fashion, and

with meticulous suturing technique and eversion, the resulting scar may be almost undetectable. On the temples, wound should be repaired in a radial fashion, with special attention paid to the baseline rhytides and vectors of tissue laxity.

Scalp

Repairs on the scalp should take into account the inelastic nature of scalp skin. Linear repairs are often limited by this inelasticity, though with subgaleal undermining (and possibly galeal relaxing incisions), even fairly large defects may be closed in a linear fashion. There is considerable individual variation in scalp elasticity, and this should always be judged by attempting lateral compression on the scalp in multiple directions prior to closure. Though debatable, considerable tissue creep may be seen in some patients, suggesting a role for intraoperative tissue expansion using either temporary sutures or a towel clamp. For a detailed discussion of repairs on the scalp, see [Chapter 44](#).

Hands and feet

Linear repairs on the hand may be subject to significant tension as well as repetitive trauma from daily exposure as well as the insertion and removal of the hand from a pocket or purse. Most linear repairs on the hand are oriented along the long axis of the hand, though depending on the orientation of the defect as well as the patient's activity level, this axis may be individualized. Transversely oriented closures may increase the risk of postoperative lymphedema due to an increased risk of lymphatic transection. Exploring the full range of motion rather than relying on RSTLs alone is helpful. The loose areolar tissue just beneath the dermis provides an excellent plane for undermining. Use particular caution with transepidermal sutures to avoid inadvertently entering or ligating one of the many small superficial vessels of the dorsal hand. For a detailed discussion of hand and foot repairs, see [Chapter 45](#).

COMPLICATIONS

As with any surgical procedure, bleeding, hematoma formation, dehiscence, and infection are the most common postprocedure complications seen with linear repairs.

Surgeons should make every effort to personally see every patient with a postoperative complication. This both serves to assuage the patient's concerns and helps the surgeon with feedback regarding optimal technique. Additionally, the surgeon is best qualified to assess whether some mild edema or erythema truly represents a complication or whether it is simply an expected part of the healing process.

Dog-ear formation is also frequently seen with linear closures, and a delicate balance between maintaining the natural curvature of the skin and not exaggerating the length of the wound must be maintained. Dog-ear correction should generally not be considered for at least the first few postoperative months, as significant wound flattening and maturation is expected within this period.

Most linear closures do not require surgical drains; for the rare patient with persistent pinpoint bleeding or a background bleeding diathesis, placement of a small Penrose, Jackson-Pratt, or wick drain could be considered, though in general it is far better to achieve adequate and meticulous hemostasis prior to wound closure. A rapidly expanding hematoma necessitates evacuation in the context of surgical revision, where the wound should be anesthetized, prepped in a sterile fashion, opened, explored, and all sources of bleeding definitively addressed. Smaller or stable hematomas may be managed conservatively.

Mild wound dehiscence should be managed with sharp debridement. Usually, local anesthetic is not required as only devitalized tissue—and often only the overlying eschar—is debrided. Patients may be seen weekly if desired, and should be advised to keep the wound bed moist with ointment application at least three times per day. It is vital to debride the advancing edges of the wound in order to maximize the chance of rapid healing. Patients should be told that postdebridement bleeding is not only expected, but desirable as well.

Active wound infections, while rare, should be cultured if possible, and empiric antibiotics may be started. True abscesses should be drained. Patients should understand that even wounds with significant postoperative complications may ultimately heal with outstanding cosmesis.

Repairs on sebaceous skin, such as the nose, may result in a scar that appears depressed relative to the surrounding skin. This may be approached with dermabrasion (or laser) postoperatively, though waiting 3 to 6 months may be prudent as the scar may improve significantly without intervention.

Persistent wound eversion, though rare, may be treated with intralesional triamcinolone injection, though this should not be considered until 6 months have passed.

POSTOPERATIVE MANAGEMENT

Even the best surgical repair can be undone by less-than-optimal postoperative care. Clear written instructions on wound care are of vital importance, and should be reviewed verbally with the patient as well. For most linear repairs, only minimal postoperative management is required. For wounds closed without transepidermal sutures, a simple adhesive film dressing may be applied immediately postoperatively. This gas-permeable film will permit the wound to breathe while providing a moist environment for wound healing. Patients should be warned that a small amount of blood or serous fluid drainage is expected, and that this will typically become trapped beneath the film dressing. The film dressing may be left in place for the next 1 to 2 weeks, depending on patient and surgeon preference. The advantage of this approach is that it requires no effort on the patient's part, particularly useful for difficult-to-reach wounds or for patients living alone. Leaving the dressing in place for more than 2 weeks may increase the risk of maceration.

For wounds closed with transepidermal sutures, film dressings remain an option, though often a nonstick dressing is simply cut to size and placed over the wound after the application of a thin film of ointment.

A moderate pressure dressing is applied postoperatively and left in place for approximately 24 hours. When placing a pressure dressing over adherent film, the gauze should extend beyond the edge of the film so that the adhesive tape holding the pressure dressing in place does not touch the film, as otherwise the film may be inadvertently removed at the time of the first dressing change.

Pressure should be sufficient to mitigate the risk of oozing, but should not restrict blood flow to the wound. Additionally, downward and inward pressure should be exerted just lateral to the wound edges, resulting in a net

effect of the wound edges being pressed together. Direct pressure over the surface of the sutured wound should be avoided, as this does not address potential space created laterally to the suture line and also serves as a distracting force against the sutures. This same principle should be emphasized to surgical assistants when they are asked to hold pressure on a partially sutured wound.

When needed, suture removal may be performed between postoperative days 3 and 10, depending on the anatomic site of the surgery and surgeon preference. For patients who are unable to return for suture removal, options include avoiding transepidermal sutures or placing the transepidermal sutures using fast-absorbing gut or fast-absorbing synthetic sutures.

For wounds covered with an adhesive film, no care is needed. For those covered with a nonstick pad, the wound may be gently cleaned once or twice daily and a thin film of petrolatum should be placed over the suture line using a cotton-tipped applicator. For wounds in dependent areas, patients should be advised to keep their legs elevated as much as possible for several weeks postoperatively.

Patients often ask about using over-the-counter scar healing aids. Most have little or no evidence of efficacy, and in general they should not be recommended. For patients with a history of true keloid formation, consideration may be given to intraoperative or immediate postoperative triamcinolone injection along the suture line, with repeat monthly treatments for maintenance, though risks, including delayed wound healing, atrophy, and telangiectasias, should be discussed with the patient. As noted above, patients should be told to expect dramatic wound eversion postoperatively, and be reassured that this is only temporary.¹⁸

CONCLUSIONS

The linear closure is the most useful and broadly applicable closure technique in dermatologic surgery. One of the great advantages of linear closures is their predictability; since the outstanding blood flow is maintained to the wound edge, these closures often result in fine-line nearly imperceptible scars when carefully designed and executed. Attention to detail and customizing approaches for each individual patient and anatomic

location serves to create closures that will ultimately be difficult to detect from a conversational distance.

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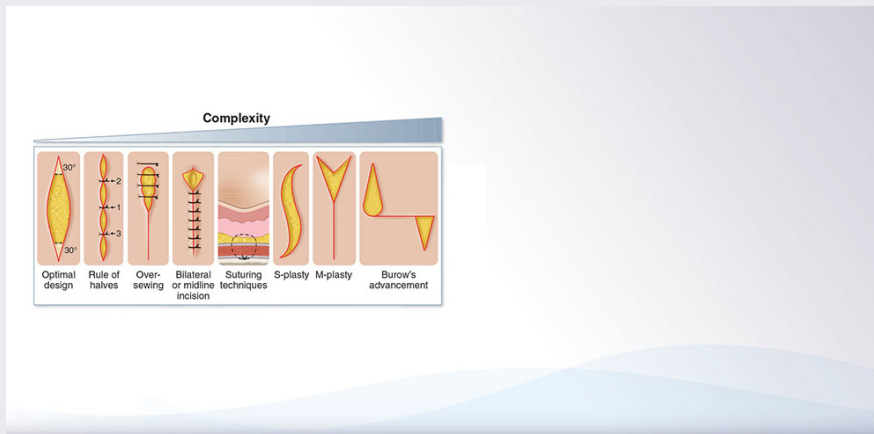
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CHAPTER 19 Dog-Ear Correction

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SUMMARY

- Dog ears, apical triangles, or standing cones are seen frequently in dermatologic surgery.
- Management of dog ears ranges from high length:width ratio reconstructive design to direct correction and beyond.
- A variety of approaches are available that are a function of anatomic location, patient preference, and desired level of surgical complexity.

Beginner Tips



- Dog ears may be avoided by appropriate closure design and execution for standard elliptical closures.
- The two most common methods for dog-ear correction are the bilateral-incision and midline-incision extension techniques.
- Post-Mohs defects are often circular and provide good opportunities to practice redundancy removal. Placing a central deep suture forms two dog ears that can be revised using any of the above techniques.

Expert Tips



- More nuanced techniques (M-plasty, S-plasty, Burow's advancement flap) may improve the outcomes in particular cases.
- These techniques are particularly useful on the face and when working around cosmetic subunit boundaries.
- On convex surfaces, specialized techniques, such as the dog-ear tacking suture, can be used.

Don't Forget!



- In certain circumstances, deferring treatment of the dog ear is acceptable.
- S-plasty correction is predicated on suture placement using the rule of halves; otherwise, there is a tendency to keep extending the repair length.

Pitfalls and Cautions



- Beware of chasing the dog ear on convex surfaces; instead, use an S-plasty or dog-ear tacking suture.
- Never treat a false dog ear; err on the side of undertreating, but be sure to outline the plan to the patient.

Patient Education Points



- All dog ears appear more dramatic in the immediate postoperative period than they will after healing; this is a function of local edema, anesthetic infiltration, and increased tension toward the center of the wound.
- Many small dog ears will resolve spontaneously with time; allow at least 2 months to assess the degree of residual dog-ear presence.

- Advising patients that all procedures are staged, so that the dog-ear correction is actively planned for a future date, minimizes stress and frustration.

Billing Pearls



- Engaging in surgical dog-ear correction is one of the ways in which a repair may move from intermediate to complex.
- If dog-ear correction is performed at a later date, be aware that this may be covered under the global period for a repair, particularly if a flap (with associated 90-day global period) was performed.

CHAPTER 19 Dog-Ear Correction

INTRODUCTION

The dog ear, also known as a standing cone, tricone, or apical triangle, is a redundancy of skin that can occur in a cutaneous closure. It can often be avoided with correct planning and a knowledge of basic principles of skin closure techniques, though some closures are designed to purposely leave a dog ear that will need correction.

PRINCIPLES OF DOG-EAR FORMATION

Wound geometry

The risk of dog-ear formation may be minimized and sometimes completely avoided with some forethought and an understanding of simple geometry. While there are many possible geometric shapes to consider for cutaneous surgery, the fusiform excision has long been established as ideal for linear closure of a wound on a flat surface. The best fusiform excision has symmetric edges of equal length, a length:width ratio of 3 to 4:1 and tapers at the ends to form 30-degree angles.¹⁻⁴ It should be noted that this shape is commonly referred to as an *ellipse*, and while this is not geometrically correct, in clinical practice, the terms *elliptical* and *fusiform* are often used interchangeably.

The geometric property that contributes most significantly to the formation (or prevention) of dog ears is the length of the wound edges relative to wound width.² If one visualizes the long axis of the excision as the line which connects the apices, it becomes clear that the sides of the wound are invariably longer than this axis. As closure approaches the apices of the

wound, the movement of the edges becomes more rotational, pivoting at the point of the apex and resulting in compression of the peri-apical skin (Fig. 19-1). When this rotational movement and compression overcome the skin's elastic qualities, a dog ear forms.^{1,3,5} Increasing the apical angle increases the rotational movement, subsequently increasing the risk of redundant tissue gathering at the apex.³ To minimize this risk, the excision should have a length:width ratio of 3 to 4:1, with apical angles no more than 30 degrees.¹⁻⁴

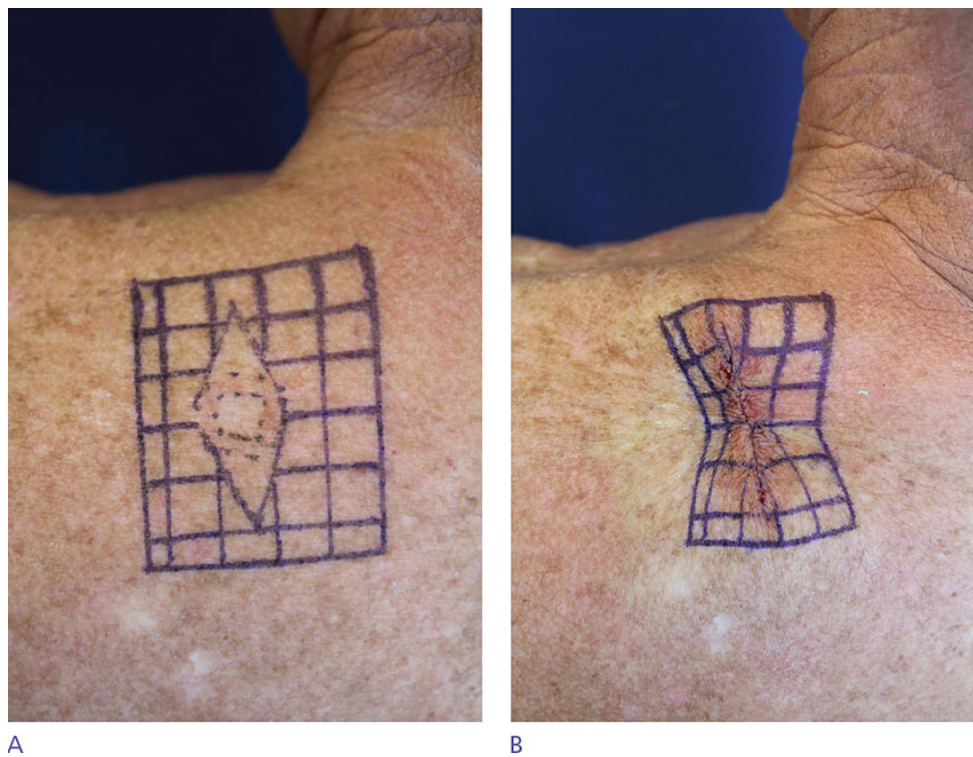


Figure 19-1. In this elliptical excision, the movement at the midpoint of the closure is pure advancement, though the apices rotate slightly as illustrated by the curvature of the lines. This rotational force contributes to tissue puckering and dog-ear formation.

In addition to the length:width ratio, the edges of the fusiform excision should be symmetric to prevent large or unevenly positioned dog ears; if the arcs are unequal, excess tissue will be gathered on the longer side and not be uniformly positioned at the apex. Correction of an uneven dog ear such as this will not result in a linear closure, but will create a curved or angled scar (crescentic repair). This may be advantageous to the skillful surgeon when trying to place a scar within natural skin lines or along favorable lines of tension.

Note also that a 3:1, and even a 4:1, fusiform excision yields apical angles significantly greater than 30 degrees. Therefore, as noted in the previous chapter, some surgeons prefer to utilize a rhombus (tangent to circle) design or other angulated closure.

Tissue dynamics

The elastic properties of the skin are important to consider when planning a closure. Skin is naturally pliant, and can tolerate a certain degree of tension or compression while maintaining a smooth, flat surface. However, the skin has defined limits of malleability, which vary with age, location, and actinic damage.¹ As stated previously, when the imposed forces which are required for closure surpass the skin's intrinsic elastic properties, dog ears can develop.¹

Because each layer of skin is anchored to the structures beneath it, undermining is an essential method for augmenting the skin's functional pliability. As an ellipse is closed, the edges pull on the underlying tissue, compressing the tissue at the base of the wound and causing vertical displacement of the wound edges.^{1,2} Undermining can release the wound edges from the anchored tissues beneath, mitigating the compression by allowing lateral dissipation of pressure as the skin is stretched.^{2,5}

Surface contour

In addition to wound geometry and tissue elasticity, the contour of the surgical site may also affect the closure and formation of dog ears. Because the geometric principles of lines and angles differ between planar and curved surfaces,⁶ the prudent surgeon must account for the curvature of the skin when preparing an excision. Due to these geometric differences, fusiform angles on a convexity should be less than 30 degrees to produce a closure result comparable to that of a similar wound on a flat surface. Conversely, on a concave surface, the wound can often be closed with angles larger than 30 degrees.⁶ In short, closure on a convex surface is more likely to produce dog ears, whereas concave surfaces are more forgiving.^{1,2}

THE FALSE DOG EAR

A distinction has been proposed to differentiate permanent standing cones (*true* dog ears) from those types of skin redundancies which are transient and resolve spontaneously. These temporary redundancies have been termed *pseudo* or *false* dog ears, as they flatten out over time without any intervention. Essentially, a false dog ear is composed of a relatively small portion of skin without an abundance of subcutaneous tissue, and its composition is such that it is able to resolve naturally. The reason these false dog ears will resolve is trifold: (1) there is not excessive underlying tissue; (2) the surrounding skin is sufficiently able to contract and stretch to accommodate redistribution of the excess skin over time; and (3) the dog-ear and wound margins have been adequately undermined.⁵ Properly undermining, especially at the apices, cannot be understated, as this maneuver allows any protruding skin to be pushed deep in the horizontal plane.⁷ Also, as skin is generally more dynamic in younger patients, the chance of full dog-ear regression increases with younger age.⁸ Understanding which dog ears will resolve spontaneously, and which require correction, is often a function of experience.

High-tension repairs, such as those on the lower leg, may also lead to changes that mimic true dog ears. When an ellipse is closed in an area under significant tension, such as the lower leg or scalp, the tension on the skin may cause central wound depression. This depression sometimes causes the tips of the ellipse to appear raised, simulating dog ears; however, this is illusionary due to the central depression. The tips are not truly redundant, and generally resolve without intervention.

TECHNIQUES FOR DOG-EAR REMOVAL

Techniques that excise the excess puckered tissue by lengthening the scar along the wound's long axis are the simplest and most frequently utilized methods of dog-ear revision (Fig. 19-2). Extending the wound increases the length-to-width ratio, thereby decreasing the apical angle, resulting in a more gradually tapered edge which can then be approximated with less rotational compression. With less compression at the apices, the less the tissue will pucker and tent. These methods are best employed when the wound is

already aligned along a favorable line of closure¹; however, sometimes simply extending the scar line will not result in a favorable outcome. In such instances, alternative approaches using more nuanced excision or suturing techniques will allow the surgeon to deliver a superior closure.

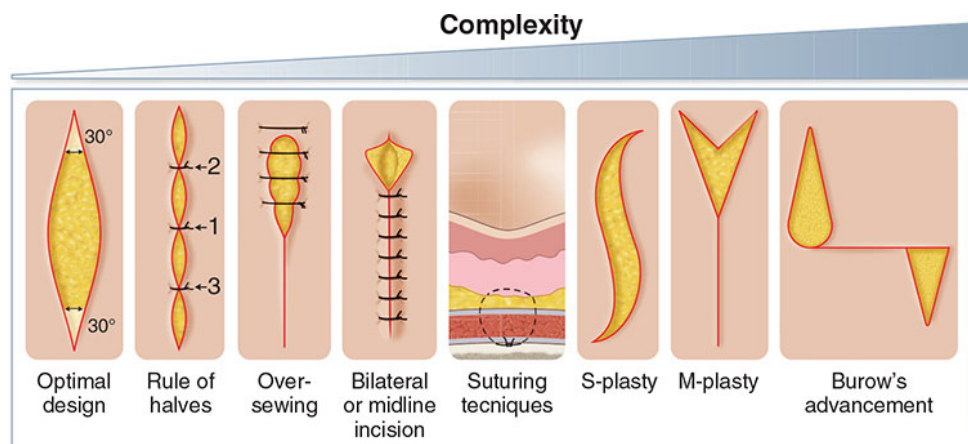


Figure 19-2. Techniques for dog ear repair.

The focus of this discussion will be on interventions for dog-ear removal. It is important to remember that leaving the redundant tissue in place with consideration for future revision is acceptable. Often the dog ear will dramatically improve and the revision procedure may involve a much smaller redundancy than was originally planned (Fig. 19-3).



A



B



C



D

Figure 19-3. Delayed dog-ear repair. Dog ears may improve spontaneously over time; even those that do not resolve completely are frequently less conspicuous than anticipated, ultimately necessitating an additional length at revision that is significantly smaller than would have been performed *a priori*. The patient presented with a significant defect of the left upper cheek/lower eyelid (A) that was closed without removing the large superior dog ear (B). At 2-month follow-up, (C) there is a very small area of redundant tissue noted just superior to the left mid nasojugal fold, on a background of slight edema. This small redundancy was removed, and the final result 4 months after the original surgery (D) demonstrates acceptable symmetry with the contralateral side.

Bilateral-incision extension technique

This approach is very straightforward, and can be used in the majority of cases. This is the primary method of dog-ear removal for the authors of this article. With practice, this technique is an efficient and elegant way to repair dog-ear redundancies:

1. Using forceps or a skin hook, grasp the apex of the dog ear and pull lightly in an outward direction until just taut. This maneuver will produce a triangular shape to the cone of tissue, with its base aligned with the original wound incision.
2. With the skin tented, it is important to note the extent of the redundancy, as this will indicate how much wound extension is required. This is denoted by the tip of the cotton-tipped applicator in the figure (Fig. 19-4A).

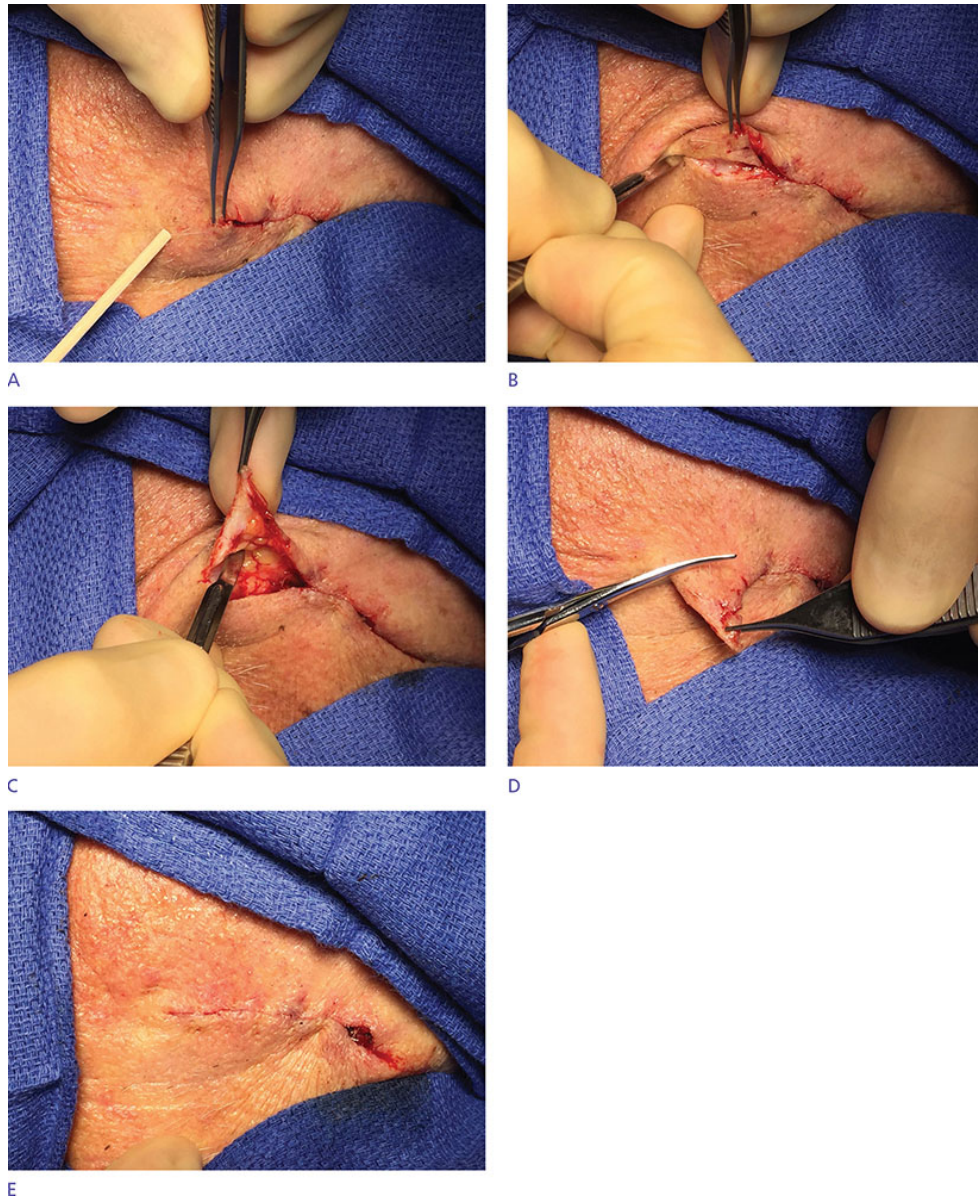


Figure 19-4. The bilateral incision extension technique. First, (A) the dog ear is gently elevated with surgical forceps, and its extent is noted (here by the presence of the cotton-tipped applicator). Then, (B) the dog ear is gently pulled laterally, and an incision is made in line with the already existing excision line. This nascent flap of skin is then undermined (C). The dog ear is then pulled in the opposite direction (D), and another incision is made. This technique results in dog-ear removal and the extension of the original excision line (E).

3. While lightly gripping the apex of the cone, drape the redundancy to one side. Then make an incision connecting the point of extension (Step 2) with the surgical wound. Particular attention should be paid to creating

an incision that aligns with the existing incision with little to no angle change (Fig. 19-4B).

4. Elevate the redundancy and undermine the flap of skin. This can be accomplished with a scalpel or scissors (Fig. 19-4C).
5. Once undermined, drape the redundant skin across the long axis of the original wound. Incise the remaining side of the redundancy along the long axis to release the tissue. Again, particular attention should be paid to creating an incision that aligns with the existing wound with little to no angle change (Fig. 19-4D).
6. Finally, closure of the wound should continue with a standard linear closure technique (Fig. 19-4E).

Midline-incision extension technique

This technique has the same result as the bilateral-incision method, utilizing a slightly different approach:

1. Using forceps or a skin hook, grasp the apex of the dog ear and pull lightly outward until just taut. This maneuver will produce a triangular shape to the cone of tissue, with its base aligned with the original wound incision.
2. With the skin tented, it is important to note the extent of the redundancy, as this will indicate how much wound extension is required, as is denoted by the tip of the cotton-tipped applicator (Fig. 19-5A).



A



B



C



D



E



F



G

Figure 19-5. The midline-incision extension technique. First, (A) the dog ear is gently elevated with surgical forceps, and its extent is noted (here by the presence of the cotton-tipped applicator). Then, (B) the dog ear is gently pulled upwards away from the skin, and an incision is made in the midline extending the already existing excision line. This area is then undermined bilaterally (C). The dog ear is then pulled gently laterally (D), and the half-triangle is removed in line with the original excision line. Finally, the dog ear is pulled in the opposite direction (E), and the process is repeated (F). This technique results in dog-ear removal and the extension of the original excision line (G).

3. While lightly gripping the apex, incise the redundant tissue directly along the long axis of the wound with a scalpel or scissors, effectively bisecting the cone into two equal triangular flaps. If working with very thin skin, the surgeon may find using scissors an easier approach (Fig. 19-5B).
4. Undermine beneath the dog ear to release the flaps of skin (Fig. 19-5C).
5. With forceps or a hook, grasp one of the flaps and drape it across the incision line (the long axis) (Fig. 19-5D).
6. Remove this flap by excising it at its base along the incision line. Be careful not to impose excessive traction when pulling the flap across the wound, as this will result in excision of excess tissue (Fig. 19-5D).
7. After the first triangular flap is removed, repeat the process with the opposite flap (Fig. 19-5E).
8. Finally, closure of the wound should continue with a standard linear closure technique (Fig. 19-5F).

ALTERNATE INTERVENTIONS

Though most dog ears can be remedied using the aforementioned interventions, in some instances, lengthening of a scar is not possible or will lead to an inferior cosmetic result. These cases may warrant more advanced approaches to achieve superior results.

M-plasty modification

This technique may be employed when lengthening of the scar would yield a suboptimal result, commonly encountered when performing surgery around certain anatomic sites, such as the eye or lip, or when the resultant lengthened scar would cross a cosmetic junction. M-plasty is used to shorten the final scar length, and additionally removes less normal skin:⁹

1. Using forceps or a skin hook, grasp the apex of the cutaneous cone and pull lightly in an outward direction. This maneuver will produce a triangular shape to the cone, with its base aligned with the original wound incision.

2. With the skin tented, note the extent of the redundancy. It may be useful to outline the base of the cone. Mark a point on each side of the cone's base that is approximately two-thirds of the length of the redundancy (Fig. 19-6A).

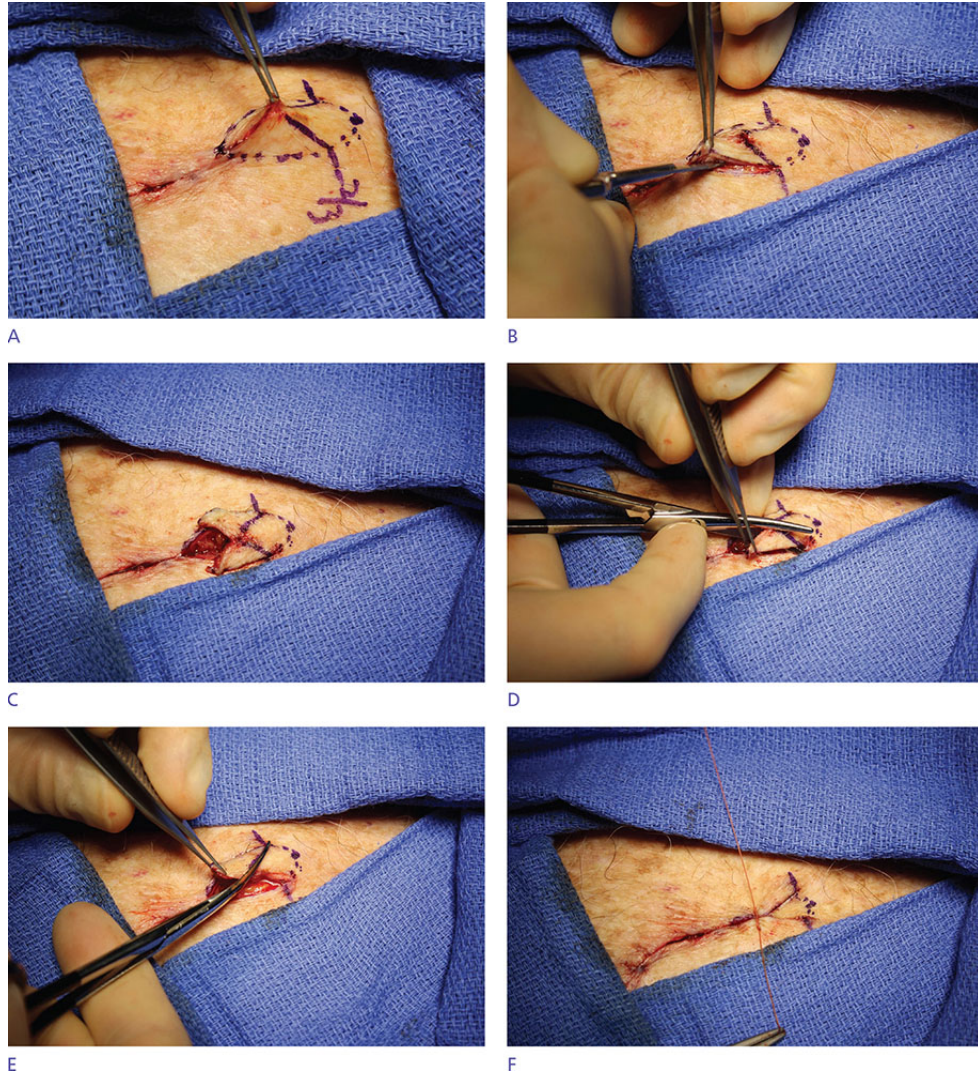


Figure 19-6. The M-plasty technique. The extent of the raised dog ear is delineated (A), and a point $2/3$ along the length of each cone's base is marked. Incise along the base of the redundancy, connecting one of the points to the existing wound (B). Repeat this step with the second point on the other side. This will result in a flap of skin that resembles a rectangle, which is only attached along one of its long edges (C). Next, excise a portion of the flap by cutting from the midpoint to the point previously marked (D) and repeat on the other side (E). A tip stitch (F) is often utilized to secure the tip of the M-plasty in place.

3. Incise along the base of the redundancy, connecting one of the points to the existing wound. Repeat this step with the second point on the other side (Fig. 19-6B). This will result in a flap of skin that resembles a rectangle, which is only attached along one of its long edges (Fig. 19-6C). Note that the apex of the original wound now terminates at the midpoint of the flap's free edge.
4. Undermine flap of skin, so it can be laid flat on the skin surface.
5. With scissors or a scalpel, excise a portion of the flap by cutting from the midpoint to the point previously marked in Step 2. Then repeat on the other side (Figs. 19-6D and 19-6E).
6. For good approximation of the tip of the M-plasty, a tip stitch (half buried horizontal mattress suture) is often utilized. Suturing of the remainder of the M-plasty is performed in a conventional fashion (Fig. 19-6F).

S-plasty modification

This technique permits redirection of the closure line of redundant tissue. This is particularly helpful on convex surfaces, such as the extremities, the chin, and the ear which often require length:width ratios much greater than the standard 3:1 to reduce the apical angle for optimal closure. Redirection of the excision has two primary benefits: (1) it guides the suture line from the convex surface onto a flatter surface, thereby mitigating the risk of “chasing” the dog ear on the convexity and decreasing the required suture line length; and (2) as scars tend to depress on convex surfaces, S-plasty redirects the depressive forces onto a flat plane, thereby decreasing the formation of such central indentation.

To perform this procedure (Fig. 19-7), the surgeon will follow many of the same steps as the bilateral-incision technique. However, rather than bisecting the cone to a point aligned with the wound's axis, a different point is selected either to the right or left of it. The further right or left the surgeon goes, the more dramatic the S-plasty. Curvilinear lines are created and the edges are undermined as needed. As one edge will be longer than the other, the rule-of-halves should be utilized when suturing to decrease the risk of forming another dog ear: the first suture approximates the midpoint of the long arc to the midpoint of the short arc, essentially halving the wound (Fig.

19-7D); the second suture then approximates the midpoints of the subsequent arcs, and so on, and so forth, the strategy continues, successively halving the wound each time until the closure is complete. The rule-of-halves allows the excess tissue of the longer wound edge to be evenly distributed along the entirety of the wound's closure, minimizing or eliminating the need for redundancy removal.

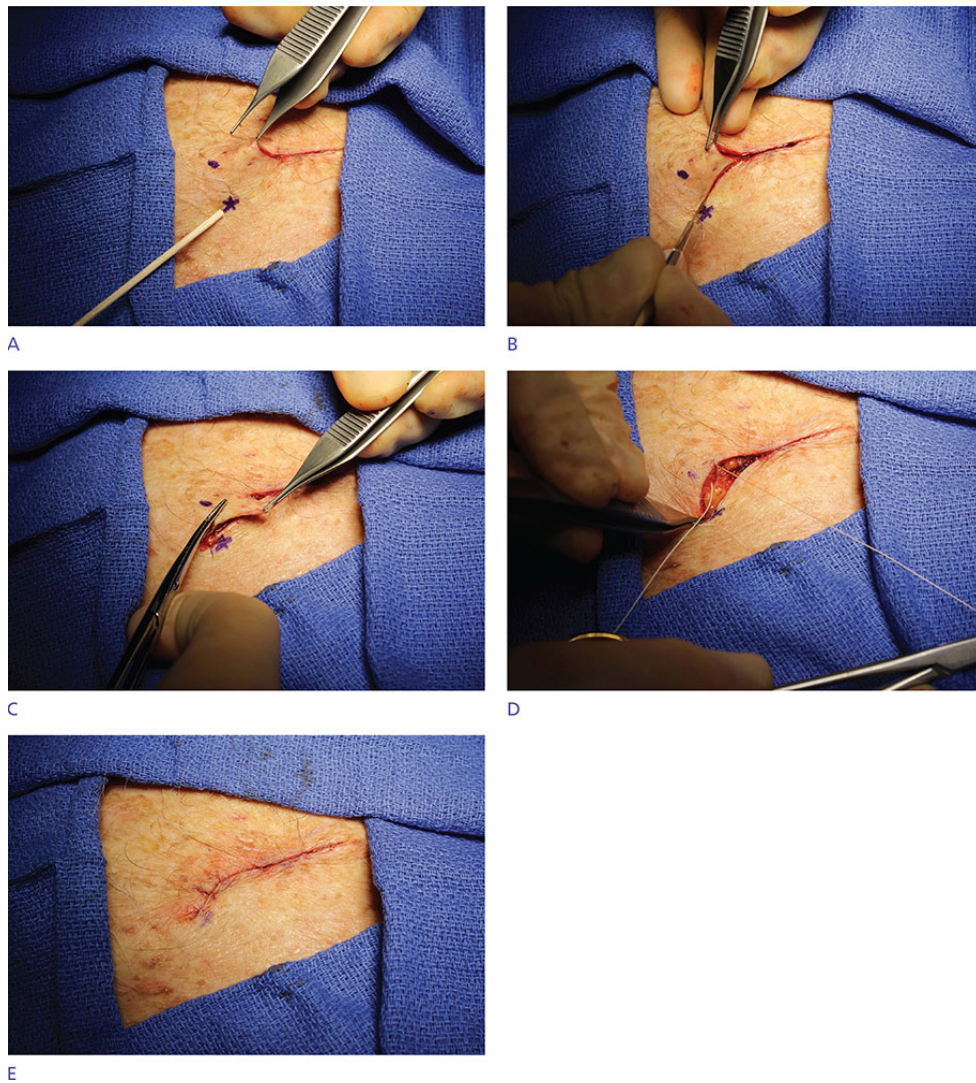


Figure 19-7. The S-plasty modification. In order to exaggerate the curve at the end of the closure, a target point (asterisk) is chosen outside of the standard dog-ear removal cone, lateral to the base of the standing cone (A). A curvilinear incision is made from the end of the existing excision line to the target point (B), and the dog ear is then draped laterally and removed (C). The first deep suture is placed in the center of the nascent dog-ear repair, using the rule of halves (D). Light tension pulling the new wound apex away from the center of the wound is helped to better delineate the precise location of the center of the repair. The final result (E) is a curvilinear repair terminating at the target point.

Burow's advancement and flap modifications

Redundant tissue needs not be excised only by directly lengthening the already-formed suture line. For example, a Burow's advancement flap may be performed by displacing the apical triangle by as much as 90 degrees. Indeed, advancement, rotation, and transposition of neighboring skin can be used to more appropriately orient a dog-ear removal, permitting the placement of additional wound length in natural creases or along cosmetic subunit boundaries. These techniques are particularly useful when the defect is present in close proximity to the borders of anatomic subunits or close to free margins. Additionally, the redundancy itself can be used for the closure, such as in a V-Y advancement flap ([Chapter 21](#)) and Burow's graft repair ([Chapter 28](#)).

Suturing techniques to decrease dog-ear prominence

Multiple techniques have been reported utilizing suturing techniques to help repair dog ears.^{10–12} They do not replace the aforementioned techniques, but rather can function as helpful adjuncts. They are particularly helpful in the correction of a small redundancy, or when a full-thickness dog-ear excision may compromise the subdermal vascular plexus. This is particularly useful when removing dog ears at the base of flap repairs in areas of poor perfusion, or in patients with comorbidities.

Several reports discuss tacking sutures to reduce the appearance of the dog ear.^{10,11} The dog-ear tacking suture is performed by placing a dermal suture at the undersurface of the apex of the redundancy followed by a suspension suture that grasps periosteum ([Fig. 19-8](#)).¹¹ Another technique utilizing a suspension suture describes a three-bite technique:¹⁰ the first throw is at the base of the dog ear, a few millimeters distal to the last subcutaneous stitch, and grabs fascia or periosteum (the suspension suture); the needle is then passed in a dermal plane (similar to a running subcuticular suture throw) along one side of the dog ear; finally, a third throw is performed along the other side. When the suture is tied, it approximates the skin of the redundancy and tacks it to the underlying fascia or periosteum.

Obviously, both of these techniques are best utilized in areas where underlying periosteum is easily available, such as the forehead.

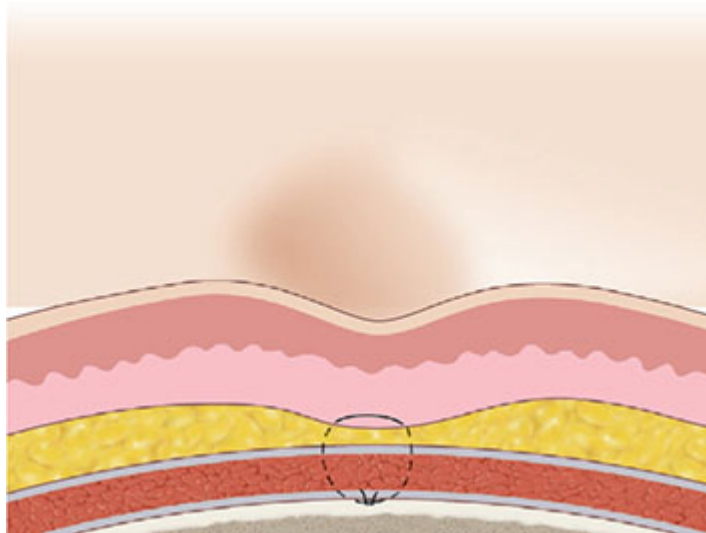


Figure 19-8. The dog-ear tacking suture.

Another novel method describes de-epithelializing the dog ear, inverting it and suturing over the redundancy.¹² This technique is more technically challenging, as it requires the surgeon to have the precision to de-epithelialize tissue which, in some cases, may be quite thin and difficult to manipulate. As with the suturing techniques described above, this does not require the removal of the subdermal vascular plexus.

CONCLUSIONS

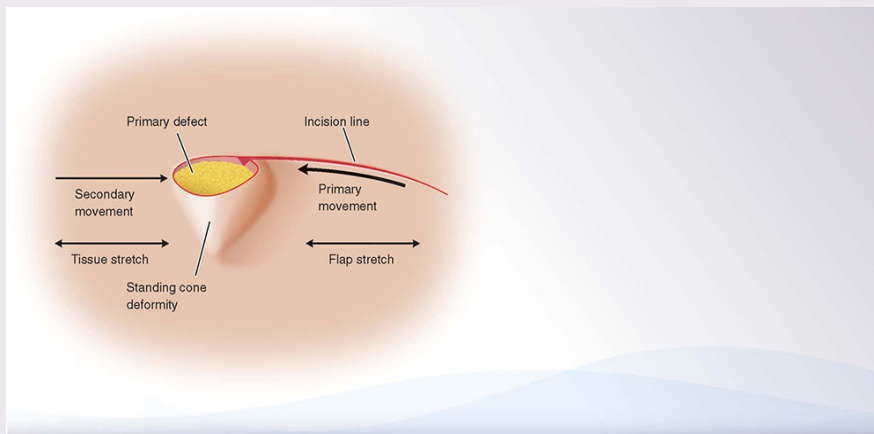
Dog-ear correction is a daily task for the dermatologic surgeon. While some surgeons aim to design linear excisions that *a priori* mitigate the risk of dog-ear formation, others prefer to excise tumors and then correct standing cones on an as-needed basis. In select cases, apical triangles may be left in place to assess their postoperative prominence after the initial healing phase. In defects from Mohs micrographic surgery, most wounds require some degree of dog-ear correction, as the defect is rarely fusiform. Repairing dog ears in a linear fashion is the most common approach, whether using the midline or double-incision approach, though other modifications, including specialized suture techniques and Burow's advancement flaps, are possible as well.

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CHAPTER 20 Principles of Flap Dynamics

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SUMMARY

- Understanding flap dynamics is a prerequisite for the performance of any flap procedures.
- Pivotal, deep, and horizontal restraints all have an important impact on flap design and execution.

- Accounting for fundamental tissue principles and flap dynamics prior to flap execution permits more successful and cosmetically appealing reconstructive outcomes.

Beginner Tips



- Understanding flap dynamics is predicated on an appreciation of the forces that oppose tissue movement.
- Undermining mitigates most deep restraint, while horizontal restraint is addressed by using a sufficiently lengthy incision that recruits lax skin.

Expert Tips



- Horizontal, deep, and pivotal restraints must all be addressed for optimal flap outcomes.
- Obstructive restraint can be addressed prior to flap movement.
- On the face, the robust blood supply means that even random pattern flaps may behave more like axial flaps in terms of viability.

Don't Forget!



- Undermining beyond 1 to 2 cm from the incision line may be counterproductive and lead to an increased risk of tissue ischemia.
- Flap length:width ratios should ideally not be significantly greater than 3:1, at least when working in poorly perfused areas such as the legs. On the face, where most dermatologic surgery flaps are performed, there is often a forgiving and robust blood supply.

Pitfalls and Cautions



- Failing to account for pivotal restraint is one of the most common flap design challenges. Appropriately oversizing rotation flaps and widely undermining the pivot point may go a long way to mitigating this problem.
- Once relocated to the primary defect, flaps should be under minimal tension.

Patient Education Points



- Patients should be warned prior to flap closure that they will have an incision stretching well beyond the initially visible defect.
- Explaining that the additional scar length will likely heal with a minimally visible line may go a long way toward patient reassurance.

Billing Pearls



- Flap repair codes (140XX series) include the excision component, so it is not appropriate to bill both an excision and a flap repair code simultaneously.
- Mohs codes may be submitted along with flap repair codes, though they may be subject to the multiple procedure reduction rule.
- When coding a flap, medical necessity is the ultimate arbiter of appropriateness.

CHAPTER 20 Principles of Flap Dynamics

INTRODUCTION

Flap dynamics are the principles that underpin the movement and behavior of all flaps. By definition, a cutaneous flap is a reconstructive technique that is composed of skin and subcutaneous tissue as well as accompanying vascular supply, which is moved from a donor site to a recipient site. The recipient site is termed the primary defect and, in the context of dermatologic surgery, usually results from the excision of a cutaneous neoplasm. Movement of the flap into the primary defect may create a secondary defect that must also be repaired.

VASCULAR ANATOMY

The skin of the head and neck has a robust vascular system that is derived from the subdermal and epidermal vascular plexuses. In the skin, the deep musculocutaneous arteries give rise to the subdermal vascular plexus, which is found at the junction of the dermis and subcutaneous tissue. Arterioles from the deep subdermal plexus supply the epidermal appendages and give rise to the intradermal vascular plexus. The intradermal vascular plexus is found in the reticular dermis and branches to form the superficial vascular plexus that ultimately becomes the capillary loop system in the papillary dermis. It is this capillary loop system that supports the metabolic needs of the epidermis. Due to low perfusion pressures and blood flow within the intradermal plexus, it is essential that the undermining of a random flap be performed in the plane of subcutaneous tissue. Inclusion of vessels of the

subdermal plexus helps to ensure adequate blood flow and viability (Fig. 20-1).^{1,2}

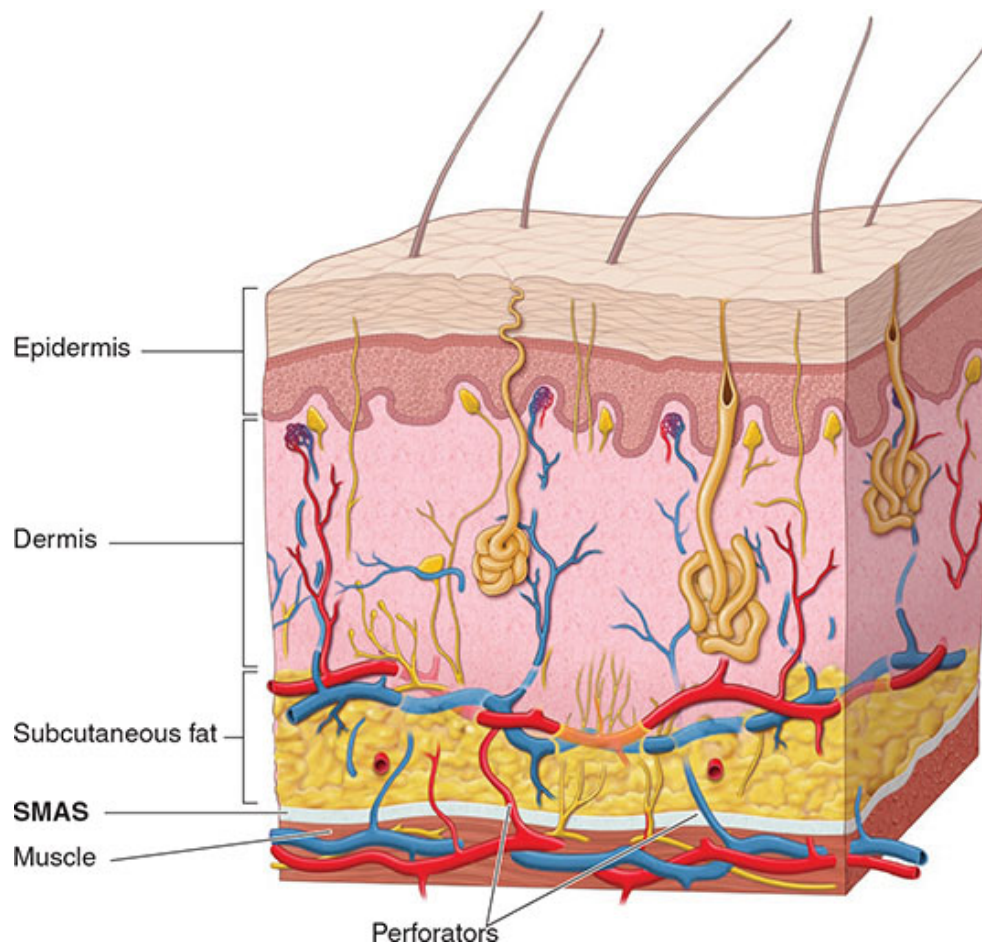


Figure 20-1. Cutaneous vascular anatomy. The subdermal plexus found in the mid to superficial subcutaneous tissue provides the vascular supply to random pattern flaps. The intradermal vascular plexus lacks the perfusion pressure and bloodflow to support cutaneous flaps alone. Deeper musculocutaneous arteries provide the vascular supply for axial pattern flaps.

STRESS–STRAIN CURVE

The biomechanical properties of skin must be considered in order to ensure flap viability and success. Like all materials, skin has unique and characteristic biomechanical properties: chief among these are stress and strain. In cutaneous surgery, stress is defined as the force applied per cross-sectional area, while strain is the change in the length divided by the original length when a given force is applied to the skin (Table 20-1).

Table 20-1. Stress and Strain

Stress	Strain
Force per unit area	Change in length divided by the original length

The nonlinear relationship between stress and strain can be visualized using a stress–strain curve. This nonlinear/nonelastic property of skin is due to its structural components, mainly collagen and elastin. In the elastic phase (Zone I) of the curve, the randomly oriented elastic and collagen fibers within the skin begin to stretch and orient themselves in the direction of the applied force. This initial deformation results in the lengthening of the tissue with minimal force, and is nearly linear or elastic. In the plastic phase (Zone II) of the curve, as force is continually applied, the lengthening continues as additional collagen fibers become aligned parallel to the direction of the applied force. In the breaking phase (Zone III) on the curve, the collagen fibers are maximally stretched and the lengthening becomes limited.^{3–7} In this final phase, large amounts of force will result in only minimal lengthening of the tissue due to the inextensible nature of fully stretched collagen fibers.⁸ Understanding this stress–strain curve is essential to flap design as high wound-closure tension, as seen in Zone III of the curve, increases the risk for tissue necrosis and flap failure (Fig. 20-2).

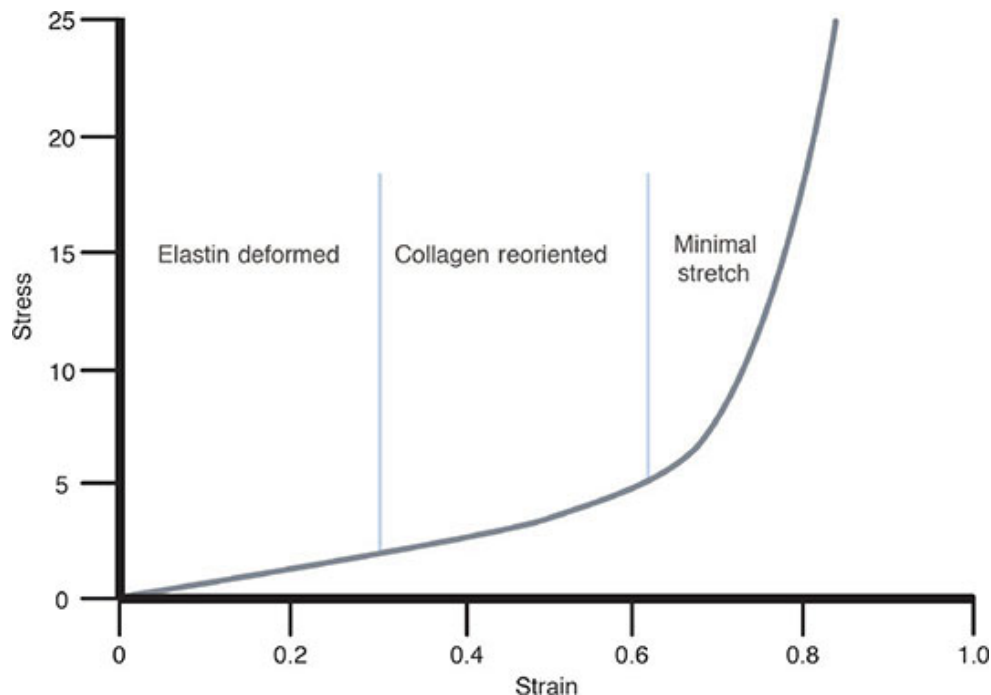


Figure 20-2. Stress–strain curve demonstrating the nonlinear properties of skin when stretched. Initial lengthening occurs with minimal force during the elastic phase (Zone I), progressive lengthening occurs during the plastic phase (Zone II), and lengthening ceases despite additional force during the breaking phase (Zone III).

VASCULAR SUPPLY

Adequate vascular supply of a flap is of paramount importance for flap survival. By definition, all flaps provide the vascular supply needed to provide the gas exchange and nutritional support required for their survival. The base or pedicle of the flap is the area that remains attached to the skin adjacent to the surgical defect and contains the source of this vascular supply. The tip of the flap is the portion of the flap furthest from the base, and is the portion of the flap that is most at risk for necrosis and failure secondary to insufficient blood supply.

Various ways to categorize cutaneous flaps exist; one such approach is to categorize flaps according to vascular supply. Using this classification system, the two main categories of cutaneous flaps are random and axial pattern flaps ([Table 20-2](#)). Random flaps include those that are supplied by unnamed arteries. In cutaneous surgery, there are a nearly infinite number of random flaps that can be designed on the face due to the abundant vascular

supply and plentiful anastomoses. Blood supply of random flaps is derived from perforators of musculocutaneous arteries at the base of the flap, and delivered to the tip by the interconnecting vessels in the dermal and subdermal plexuses. Axial flaps, in contrast, are those that incorporate a named artery within their pedicle; this named septocutaneous or musculocutaneous artery runs within the long axis of the flap. When a flap extends beyond the reach of the named artery, the distal portion is functionally a random pattern extension of the axial pattern flap. In dermatologic surgery, the most commonly encountered axial flap is the paramedian forehead flap, deriving its blood supply from the supratrochlear artery.

Table 20-2. Flap Categorization Based on Vascular Supply

	Random	Axial
Blood supply	Unnamed blood vessel	Named artery
Number of options	Infinite	Finite
How frequently utilized	Frequently	Infrequently

In planning a cutaneous flap, various forces that affect end perfusion must be considered. Vascular perfusion pressure is the force of blood flow through a vessel; this force must be greater than the capillary resistance in order to maintain vessel patency. As expected, perfusion pressure decreases as the distance from the feeding vessel increases. If the distance becomes too great, perfusion pressure will fall below the critical closing pressure of the vessel, and necrosis will occur due to lack of blood supply.⁹ This inverse relationship between the distance from the feeding vessel and perfusion pressure historically dictated that flap length:width ratios should be in the order of 3:1 to ensure adequate vascular supply. This theory was challenged by work performed by Stell in 1979 that showed that while viable flap length is dictated by the width of the base, there is an upper limit of length survival that cannot be increased by widening the base of the flap (Fig. 20-3).⁹⁻¹⁴

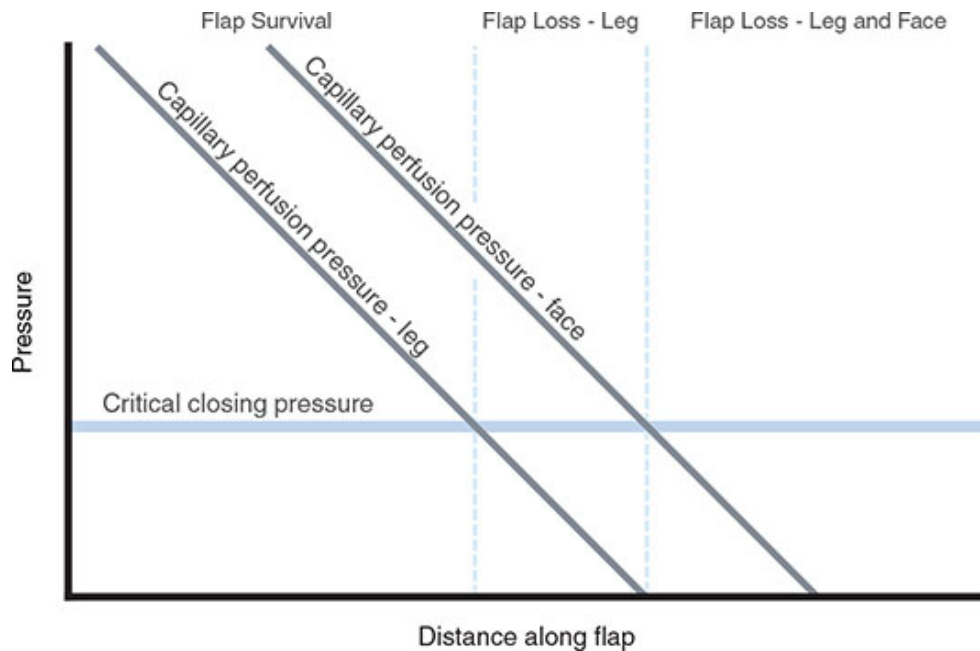


Figure 20-3. Flap perfusion and critical closing pressure. Perfusion pressure decreases as the distance from the artery and arterioles supplying the flap increases. Once capillary perfusion pressure falls below capillary resistance, blood flow ceases and distal flap necrosis occurs. Note the dependence on location, since areas with higher perfusion pressure, such as the face, are more forgiving.

In addition to perfusion and closing pressures, tension exerted on the blood vessels with the movement of the flap must also be considered. In general, movement and blood supply work countercurrent of each other. Just as in a flexible rubber tube, when tissue is stretched in order to close the primary defect, tension on the vessels will result in narrowing and ultimately the closure of the lumen if tension becomes too great. While this is a fairly minor consideration on the head and neck where blood supply is abundant, it is a major consideration on the trunk and extremities and in irradiated or heavily scarred areas where blood supply may be more tenuous.

FORCES OF CLOSURE

Despite many different techniques and variations in the planning and design of flap reconstruction, each flap repair shares a commonality regarding the forces that govern its closure. The ultimate closure of a flap is the result of four or more vectors of movement. First, the skin flap is moved into the primary defect; this movement defines the primary movement of the repair.¹⁵

The tissue surrounding the primary defect also moves inward toward the defect, creating secondary tissue movement. These two vectors are typically in opposite directions to one another.^{15,16} The flap itself and the skin surrounding the primary defect also undergoes stretch, creating two additional vectors of movement. The combination or the sum of these four vectors will ultimately define the wound closure tension across a repair's suture lines (Fig. 20-4). If all of these vectors are not appropriately accounted for, a repair may be inadequately sized to fill the primary defect, or flap failure could result secondary to necrosis or other complications. Higher wound-closure tension may also result in an increased risk of distortion of normal anatomic boundaries.¹⁵

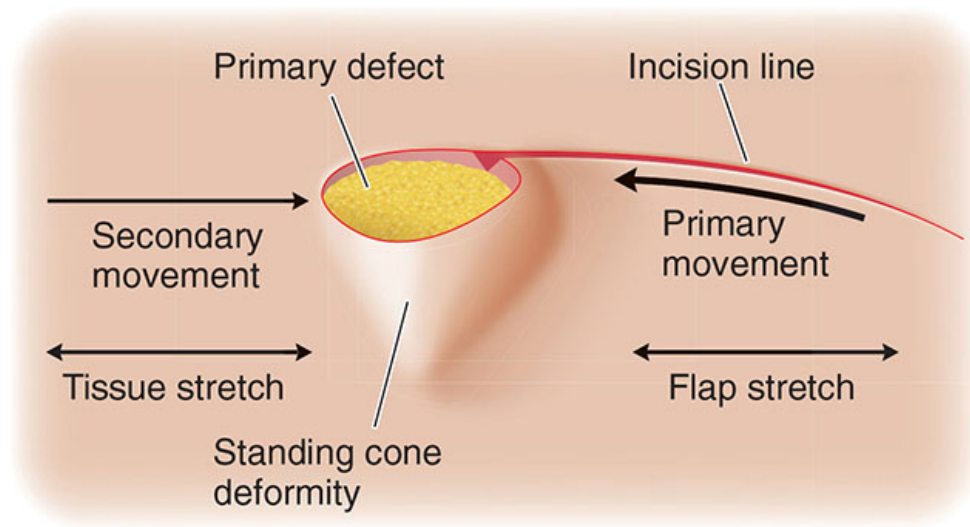


Figure 20-4. The closure of a flap is the result of four vectors of movement. Primary movement is created as the flap is moved into the primary defect. The tissue surrounding the defect moves inward toward the defect creating secondary tissue movement. Both the skin of the flap as well as the skin surrounding the primary defect also undergo stretch, creating the final two vectors of movement. The sum of these four vectors ultimately defines wound closure tension.

The ultimate wound tension and final closure vector is also influenced by the property of skin extensibility (mechanical creep) and stress relaxation. These two properties are time-dependent factors of the skin in response to tension, and can alter the vectors of closure. Skin extensibility refers to the lengthening or stretching of skin secondary to the lengthening of elastic fibers when constant tension is applied. There are directional variants to extensibility, and they are found to be at a maximum along lines of maximum

extensibility in the skin. Thus repairs should ideally be planned parallel to relaxed skin tension lines, creating the vector of tension perpendicular to the repair and along a line of maximum extensibility, ultimately minimizing the appearance of the scar. An additional vector of flap closure, stress relaxation, also occurs as the skin undergoes creep. As the skin lengthens, the stress or tension across the wound or suture line decreases. While these two factors may ultimately influence the final vector of closure, they should not be used or relied upon during flap design.¹⁷ The composition of skin, specifically the dermis, and the presence of age-related changes, atrophy, or actinic damage will ultimately influence the four vectors of closure, increasing the ability of the skin to undergo not only primary and secondary movement but also stretching or lengthening in all directions (Table 20-3).

Table 20-3. Extensibility and Relaxation

Extensibility (Mechanical Creep)	Stress Relaxation
Lengthening or stretching of skin secondary to the lengthening of elastic fibers when constant tension is applied	As the skin lengthens, the stress or tension across the wound or suture line decreases

RESTRAINT

In addition to the forces involved in wound closure discussed above, a similar set of forces have been defined which serve to limit the primary motion of a flap. These factors serve as variants of *restraint*: negative vectors that work to counteract a flap’s primary movement.¹⁸

These vectors can be found in several different directions along a repair. The skin surrounding a raised flap exerts tension in the opposite direction of the new, desired movement of the tissue flap, creating *horizontal restraint*. The tissue underneath a flap, due to its connections to deeper structures in the skin, can exert *deep restraint*, a downward vector that may limit the desired movement of a flap (Fig. 20-5). Undermining around the flap pedicle, the wound base, and the surrounding skin involved in the repair may minimize the magnitude of this restraint. Extensive undermining, however, is not required, and may risk damage to critical structures and even impair blood

flow. Most of the benefits from undermining are seen within the first 1 to 2 cm out from the wound edge.¹⁷

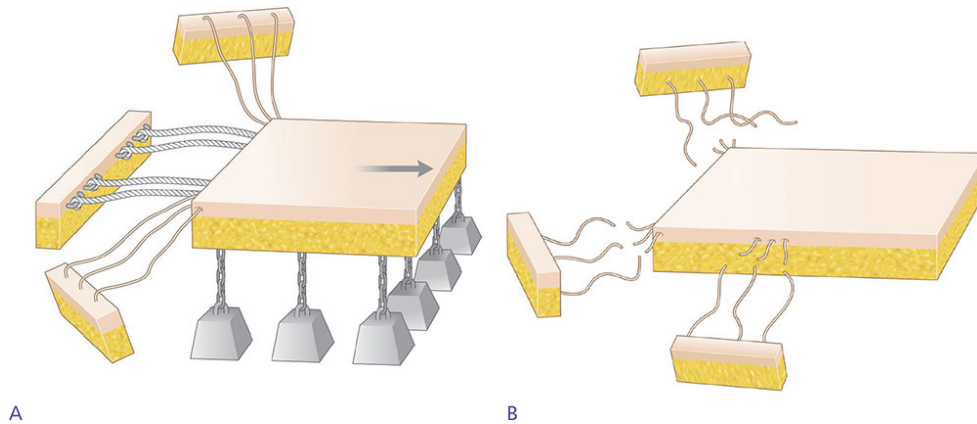
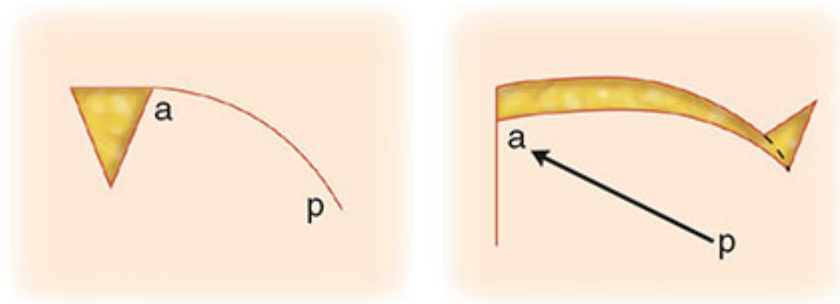


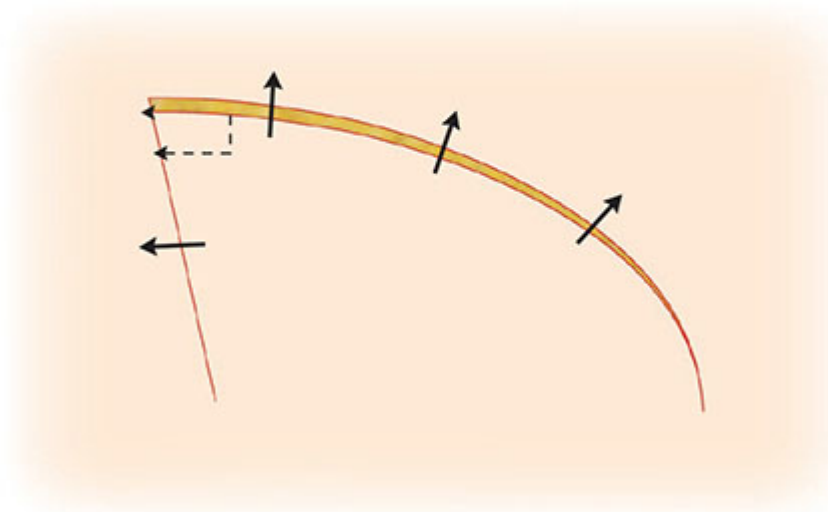
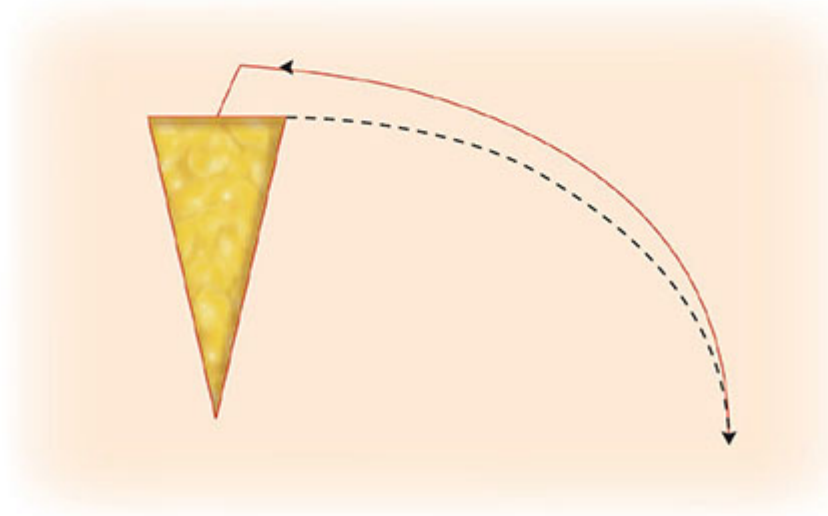
Figure 20-5. (A) Prior to the incision of an advancement flap, the surrounding skin creates horizontal restraint. (B) Undermining a flap removes deep restraint, which is secondary to the flap's connections to underlying deep structures.

In flaps undergoing rotational movement, the pedicle, or attachment, creates a focus of *pivotal restraint* that can limit movement of the flap into the primary defect. The amount of pivotal restraint is also influenced by the elasticity of the skin and is magnified in thicker, less flexible skin and minimized in thinner, more elastic skin. This tethering can be seen in flaps such as rotation and transposition flaps (as well as many advancement flaps) that undergo pivotal movement, and must be taken into consideration when planning these repairs. Otherwise, the planned flap may not fill the primary defect, resulting in increased secondary movement, increased closure tension, and potentially distortion of neighboring free margins, anatomic boundaries, or flap-tip necrosis.

For rotation flaps, the leading edge of the flap can be extended to compensate for the rotational shortening caused by pivotal restraint. For transposition flap repairs, which involve two foci of pivotal restraint, the leading edge of the flap must be longer than the sides of the defect to avoid complications from pivotal restraint. Both of these modifications result in the necessity of removing a dog ear of redundant tissue during the repair because of the length discrepancy between sides; most importantly, however, this mitigates the risk of vascular compromise or anatomic distortion (Fig. 20-6).¹⁹



A



B

Figure 20-6. (A) A rotation flap is planned. The rotational movement of the flap creates a focus of pivotal restraint or rotational shortening. This limits the primary movement of the flap and the planned

flap does not completely fill the primary defect. (B) One can compensate for pivotal restraint by extending the leading edge of a rotation flap. This allows for full closure of the primary defect without unnecessary tension.

Redundant collections of skin or dog ears are often created during both flap repairs and fusiform closures due to the forced movement of tissue. Their presence creates obstructive restraint against primary flap movement as the extra tissue functions as a physical barrier, impeding the desired movement. The creation of standing cones is influenced by the presence of length discrepancies between wound edges, the required rotational angle of movement, skin elasticity, and the surface contour in the area of the repair. The pivot, or angle of rotation, and the size of the resulting standing cones are positively associated with one another; the larger the required angle of rotation, the larger the cutaneous deformity and thus obstructive restraint.¹⁵ Careful planning may decrease the significance of obstructive restraint; if standing cones of tissue were to develop, there are many surgical options which facilitate their removal and a proper closure, as detailed in [Chapter 9](#) (Fig. 20-7).^{15,20,21}

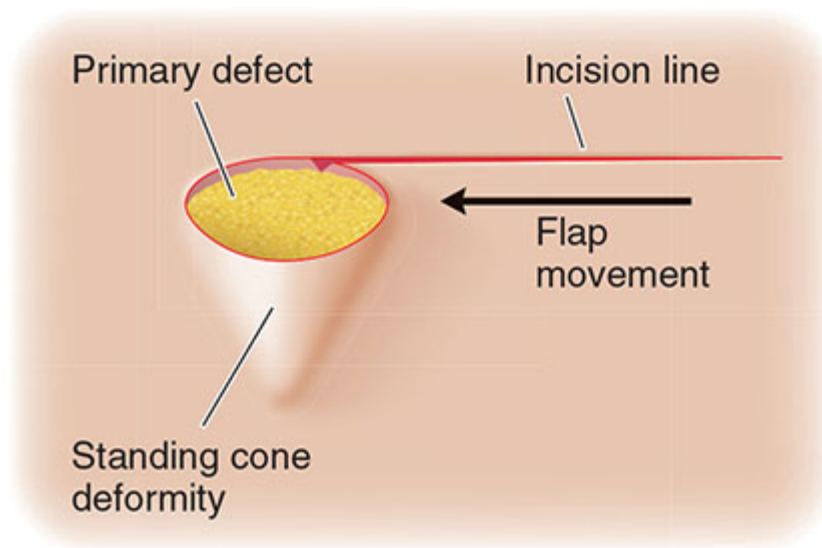


Figure 20-7. Compression of a standing cone deformity or dog ear provides a focus of obstructive restraint against primary flap movement as the extra tissue functions as a physical barrier impeding the desired primary movement.

FLAP TYPES: SLIDING AND LIFTING

Flap repairs may be classified in many ways, though when discussing their use for the repair of facial defects, it is straightforward to subdivide them into two categories, sliding or lifting, based on the overall tissue movement required (Table 20-4). The predominant movement in sliding flaps is direct translational movement of the flap into the primary defect. This creates a secondary defect, which typically has unequal wound-edge lengths, and is often closed with the assistance of removal of standing-cone deformities. The key, tension-bearing sutures are placed to close the primary defect. Both advancement and rotation flaps represent examples of sliding flap repairs.^{22,23}

Table 20-4. Sliding and Lifting Flaps

	Sliding	Lifting
Flap types	Advancement, rotation	Transposition
Movement	Direct translational movement	Lifting over bridge of normal tissue
Key suture placement	Primary defect	Secondary defect

Lifting flap repairs involve initial upward movement of the flap across a bridge of normal tissue to close the primary defect. As opposed to sliding flaps, the key, tension-bearing sutures are used to close the secondary defect. Transposition flap repairs, both single and multistaged, are examples of commonly performed lifting flap repairs.^{22,23}

All flaps must move from the donor site into the recipient site; this movement can be accomplished in various ways, depending upon the flap type. Irrespective of the flap type, movement is maximized through minimization of restraint. Any repair, including all flaps, should be designed to obey the following hierarchy; first, preserve or reproduce the functionality of the involved area; second, avoid distortion of free margins; third, maintain incisions within cosmetic unit or subunit junctions whenever possible; and finally, conform incisions to relaxed skin tension lines (Table 20-5). A thorough understanding of the dynamics and limitations of flaps will aid in planning flaps to satisfy the above criteria.

Table 20-5. Closure Hierarchy

I	Preserve function
II	Avoid free-margin distortion
III	Place incisions within cosmetic subunit boundaries
IV	Situate incisions in relaxed skin tension lines

DYNAMICS AND RESTRAINT OF ADVANCEMENT FLAPS

The advancement flap is one of the simplest flaps employed by the cutaneous surgeon. The fundamental purpose of all the advancement flaps is to achieve a greater degree of tissue movement than would be achieved by primary closure with undermining alone.²⁴ Commonly used advancement flaps in dermatologic surgery include the unilateral (O-U or O-L), bilateral (O-H or O-T), and V-Y (or island pedicle) advancement flaps.²⁵ Execution of these flaps involves the linear movement of tissue from donor to recipient site. With movement of the flap, one or more standing cutaneous deformities (dog ears, or standing cones) are created by compression of redundant skin during tissue movement.²⁶ For single tangent advancement flaps, these standing cones will form adjacent to the primary defect and at the terminus of the flap incision. For double tangent advancement flaps, the standing cones will develop at the terminus of each of the two parallel flap incisions. Double advancement flaps are created by simply mirroring two single advancement flap designs on opposite sides of the primary defect. The V-Y or island pedicle flap differs from the previously described advancement flaps in that it derives its vascular supply from a subcutaneous pedicle, and is devoid of all epidermal or dermal connections.

Due to the linear movement of advancement flaps, all flaps of this type are subject to horizontal, deep, and obstructive restraint. Horizontal restraint is released by making the flap incision. The longer the flap incision, the more horizontal restraint is released. In general, greater movement is achieved in areas of lax skin; thus, greater movement can be achieved if flap incisions extend into areas of tissue laxity. Therefore, whenever possible, the terminus of advancement flap incisions should lie in the areas of lax or mobile tissue

(Fig. 20-8). Recruiting this lax tissue reservoir allows lengthening (strain) with minimal force (stress), movement corresponding to Zone I on the stress–strain curve. Determination of an appropriate tissue reservoir should be completed early on in planning, as lack of tissue laxity available for advancement will undoubtedly adversely affect flap performance. A minimum requirement of all advancement flaps is to fully undermine the incised flap in order to release deep restraint and maximize movement. Undermining should include the undersurface of the flap and the area beneath the terminus of the flap incision, as this area must move toward the primary defect to maximize flap movement. Failure to release both horizontal and deep restraint simultaneously will result in a flap which does not function as anticipated. Excision of the standing cutaneous deformity adjacent to the primary defect eliminates this obstructive restraint in single tangent advancement flaps. In addition, excision of a standing cutaneous deformity at the terminus of the flap incision may also improve movement. While a curvilinear incision made along the limb of the flap may help redistribute tissue redundancy, eliminating the need for standing cone removal, this modification may also decrease the overall movement of the flap.²⁷



Figure 20-8. (A) A single tangent advancement flap is designed to repair a defect of the upper eyelid. The flap incision is made in order to reach the adjacent tissue reservoir in the temple. (B) Flap sutured into place. (C) Three-month follow-up.

DYNAMICS AND RESTRAINT OF ROTATION FLAPS

Rotation flaps comprise the second category of sliding flap repairs. These random pattern flaps are designed in a curvilinear configuration, which extends directly from the primary defect. One of the primary defect's wound

edges, therefore, becomes the leading edge of the flap.²⁸ The inherent rotational movement of these flaps redistributes the vector of tension along the wound. A semicircle flap is raised and rotated into the primary defect. The first key suture is then used to close the primary defect. By closing the primary defect, a secondary, crescent-shaped defect is created along the trailing edge of the flap. The length of the flap directly determines the ultimate shape and size of the secondary defect: The larger the flap, the narrower and longer the size of the secondary defect. Planning to allow advantageous placement and easy closure of the secondary defect is key to successful execution of rotation flaps (Fig. 20-9). The narrower the secondary defect, the less tension that is then required to close the surgical wound completely.²³



Figure 20-9. (A) Rotation flap designed to close a 4-cm defect of the lower eyelid and cheek. Note that the flap incision is designed to go above the level of the intercanthal line. This ensures that no portion of the secondary defect of the flap is beneath the lower eyelid, thus preventing downward

tension on the lower lid and subsequent ectropion with secondary defect closure. (B) Flap sutured into place without tension on the lower lid. Note that a Burow's graft was used to resurface a portion of the secondary defect. (C) Three-month follow-up with a good cosmetic and functional result.

Rotation flaps are often best suited for the closure of triangular defects, thus the creation of a triangular defect prior to initiation of reconstruction can help eliminate the typical Burow's triangle or dog ear which results along the inferior aspect of the primary defect as the flap is rotated into place. The arc of the rotation most effectively minimizes wound tension at an angle of 90 degrees from the axis of defect. Increasing this further has minimal effects on amelioration of wound tension.²⁹⁻³¹ When planning a rotation flap repair, the length of the flap should be approximately four times the width of the triangular primary defect, as this can avoid the removal of an equalizing Burow's triangle.²⁸

The concept of restraint also influences the success of rotation flaps. The impact of horizontal, deep, and obstructive restraint on the outcome of a rotation flaps is similar to that seen in advancement flaps. To minimize horizontal or lateral restraint, rotation flaps should be designed in such a way that the flap terminus reaches an area of increased skin laxity or a mobile tissue reservoir. The rotation flap also must be undermined to release its deep attachments, thus decreasing the deep restraint and allowing for adequate primary movement of the rotation flap. Standing cutaneous deformities, or foci of obstructive restraint, can develop at a few sites along a rotation flap's incision lines. Initial excision of a triangular standing cutaneous deformity at the inferior aspect of the primary defect will allow for increased primary movement. Standing cutaneous deformities can also be removed along any portion of the superior curvilinear incision to compensate for the length discrepancy between the two arcs and avoid obstructive restraint.

Pivotal restraint is a key factor in rotation flap design. The pedicle of the flap and its connections to the surrounding skin and structures define a maximum amount of rotation allowed by the flap, thus limiting the main primary movement of rotational flap repairs.

In order to compensate for the pivotal restraint of rotation flaps, two modifications are often employed: the leading edge of the flap can be extended beyond the defect, or a back cut can be made into the flap pedicle. The extension of the leading edge allows the flap terminus to completely

close the primary defect without placing significant tension along the key sutures. A back cut will also allow increased movement but does incur a risk of compromising or decreasing the vascular integrity of the flap. A back cut can also lessen the deep and horizontal vectors of restraint. Pivotal restraint is a function of the angle of rotation of the flap; larger angles of rotation result in a higher degree of rotational shortening. Pivotal restraint will also increase in areas of thicker, more immobile tissue, as it is a function of the local tissue characteristics. It is imperative that a surgeon plans to compensate for pivotal restraint prior to the initial incision, as it is much more effective to alter the surgical plan initially rather than relying on intraoperative adjustments when an improper closure is encountered.^{19,29}

DYNAMICS AND RESTRAINT OF TRANSPOSITION FLAPS

The main advantages of transposition flaps are their ability to tap into adjacent tissue reservoirs as well as redirect tension vectors during closure. Movement of a transposition flap includes the lifting of the flap over intact intervening skin from a donor to a recipient site. The primary vector of tension in transposition flaps is always borne across the terminal defect, the defect furthest from the primary defect, that is, the secondary defect for single-lobed transposition flaps, the tertiary defect for bilobed flaps, and so on. Transposition flaps undergo pivotal movement to reach the primary defect. The single-lobed transposition flap, including the rhombic flap and its modifications, as well as bilobed and trilobed flaps (which have a rotational component as well), are the most commonly used single-stage transposition flaps in dermatologic surgery.

By virtue of their movement, all single-stage transposition flaps are subject to horizontal, deep, obstructive, and pivotal restraint. In order to minimize horizontal restraint exerted by the surrounding tissue, it is essential to ensure that the flap is fully incised down to the plane of undermining. Movement, and thus successful execution, of this flap will be hindered by even a small dermal or muscular attachment that remains due to failure to fully incise the flap. In order to eliminate deep restraint, it is important to realize that the “true” flap (the area of the flap that rotates) includes the entire surface between the base of the standing cutaneous deformity and the

terminus of the flap. As with all other flap types, it is essential that the deep attachments at the terminus be released to allow for unrestrained movement. Preexcision of the standing cutaneous deformity that is formed in the execution of this flap type helps to reduce any obstructive restraint, and is often performed first. Pivotal restraint, leading to effective shortening of the flap, may be minimized by decreasing the angle of rotation of the flap. Minimizing pivotal restraint is an especially important consideration in thicker skin due to the likelihood of significant rotational shortening (Fig. 20-10). Anticipating pivotal restraint helps to inform the selection between single-lobed, bilobed, and trilobed transposition flaps, and thus must be considered in the early planning stages of reconstruction (Table 20-6).



Figure 20-10. (A) A trilobed flap is designed to repair a 1.5-cm defect on the nasal infratip. Due to the highly sebaceous nature of the tissue and the inherent risk of rotational shortening, the flap radius is oversized to account for pivotal restraint. (B) Flap sutured into place without distortion of alar-free margins. (C) Three-month follow-up with excellent nasal symmetry.

Table 20-6. Types of Flap Restraint and Their Management

Horizontal	Flap incision, ideally into an area of laxity
Deep	Undermining
Obstructive	Dog-ear (standing cone) removal
Pivotal	Extend leading edge; back cut in the pedicle

DYNAMICS AND RESTRAINT OF INTERPOLATION FLAPS

Interpolation flaps comprise a unique subset of transposition flap repairs. They involve the lifting and movement of tissue across normal skin that is uninvolved in the primary defect. As opposed to transposition flaps, the bridge, or stalk of tissue, is left in place for several weeks to allow for adequate neovascularization to take place between the flap and the primary defect. Therefore, these repairs require multiple stages before they are complete. The two most common types of interpolation flap repairs include the paramedian forehead flap and the melolabial or nasolabial interpolation flap. The Abbé flap, or lip switch flap, is another interpolation flap frequently used for full-thickness defects of the lips.

All interpolation flaps arise from a rich vascular pedicle, either axial or random in origin, involve donor sites that are distant and noncontiguous from the primary defect, and (generally) require two or more stages for completion.³² Regardless of whether the flap is considered random or axial in pattern, these flaps are derived from areas with a robust blood supply. This increased vascularity allows for the increased flap length without significantly increasing the risk of distal flap necrosis when compared with other types of flap repairs. Once the flap has been incised and elevated, the deep and horizontal restraint forces are minimal for interpolation flaps. Interpolation flaps, however, are still limited by pivotal restraint, as it is the flap pedicle that limits rotation of the tissue into the primary defect. This can be lessened by the construction of a narrow pedicle, made possible by the axial or robust vascular pattern that provides the support for these flap repairs, ensuring sufficient blood supply to the flap terminus (Fig. 20-11). While such repairs may be more involved than random pattern flaps, they

have proven to be safe and successful options for extensive defects on the distal nose.^{32–35}



Figure 20-11 . An islanded modification of the melolabial interpolation flap creates a more flexible pedicle thus minimizing the risk of pivotal restraint.

CONCLUSIONS

Understanding the principles of flap dynamics is a prerequisite for successful flap design and performance. These principles range from the basics of tissue stress and strain through the concepts of restraint in all of its forms. Many common errors in flap design are rooted in a less-than-thorough appreciation of the fundamentals of flap dynamics. Therefore, a comprehensive appreciation of the importance of these principles—especially the concepts of pivotal, horizontal, deep, and obstructive restraints, and how to mitigate them—is of critical value prior to embarking on independent flap design.

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CHAPTER 21 Advancement Flaps

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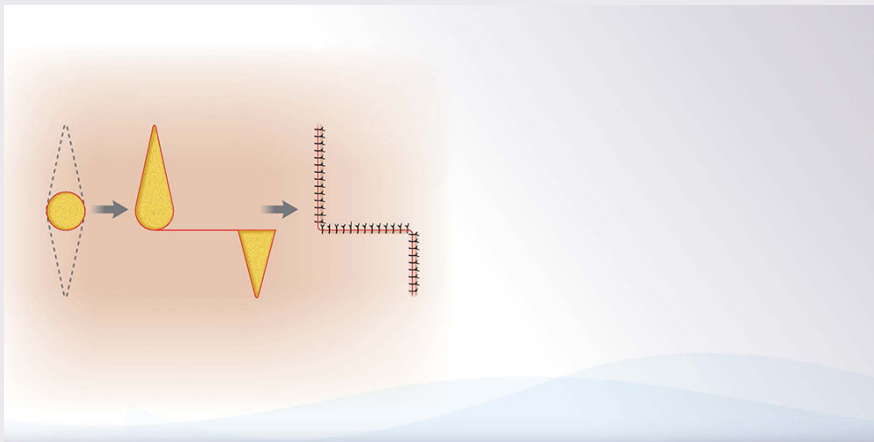
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SUMMARY

- Advancement flaps are among the most frequently performed flaps in dermatologic surgery.

- These flaps may be conceptualized as a geometric variation of a linear closure, resulting in dog-ear redistribution and tension release.

Beginner Tips



- Advancement flaps may seem deceptively simple; handling of the displaced dog ears, however, requires a thorough appreciation of tissue dynamics.
- As with all flaps, advancement flaps lead to a significantly extended suture line compared with a linear closure. Therefore, attention to detail in suturing techniques is of vital importance to camouflage the scar as effectively as possible.

Expert Tips



- Combining advancement flaps with suspension (tacking) sutures may be very useful around free margins.
- Advancement flaps may be combined with other approaches such as grafts (typically Burow's grafts harvested from the dog ears), partial closures, and SMAS plication.
- Crescentic advancement flaps may obviate the need for secondary dog-ear removal.

Don't Forget!



- Excessive undermining may be unnecessary and may increase the risk of tissue ischemia.
- Always keep in mind the maximal flap length to pedicle width ratios when designing advancement flaps.

Pitfalls and Cautions



- Never force an advancement flap; while this design may seem most straightforward, some situations call for other approaches.
- Always tailor flap design to the individual patient; flap elevation and undermining in patients on aspirin or anticoagulants may increase the risk of hematoma formation.
- When in doubt, consider drain placement in these patients, even after meticulous hemostasis has been obtained.

Patient Education Points



- Patients should be warned prior to flap closure that they will have an incision stretching well beyond the initially visible defect.
- Explaining that the additional scar length will likely heal with a minimally visible line may go a long way toward patient reassurance.

Billing Pearls



- Flap repair codes (140XX series) include the excision component, so it is not appropriate to bill both an excision and a flap repair code simultaneously.
- Mohs codes may be submitted along with flap repair codes, though they may be subject to the multiple procedure reduction rule.
- When coding a flap, medical necessity is the ultimate arbiter of appropriateness.

CHAPTER 21 Advancement Flaps

INTRODUCTION

Local random pattern flaps are workhorse reconstructive options for cutaneous defects. Advancement flaps are conceptually the simplest local flaps and fall within the group of *sliding flaps*, in which tissue is moved directly into the adjacent defect without *lifting* it over interposed tissue. Unlike rotation flaps, pure advancement flaps do not create significant secondary defects, and the leading edge of an advancement flap is not typically restricted significantly by pivotal restraint.

PRINCIPLES OF ADVANCEMENT FLAP DESIGN

Advancement flaps may be conceptualized as modified linear closures, with one or both apical standing cones (dog ears) moved laterally to facilitate aesthetic or functional closure. When a free margin such as the eyelid or lip, or a cosmetic subunit junction, would be violated by a linear closure, advancement flaps may be utilized to direct the standing cones away from these natural boundaries (Fig. 21-1). Additionally, advancement flaps often camouflage scars by placing incision lines along natural creases or cosmetic subunit junctions.

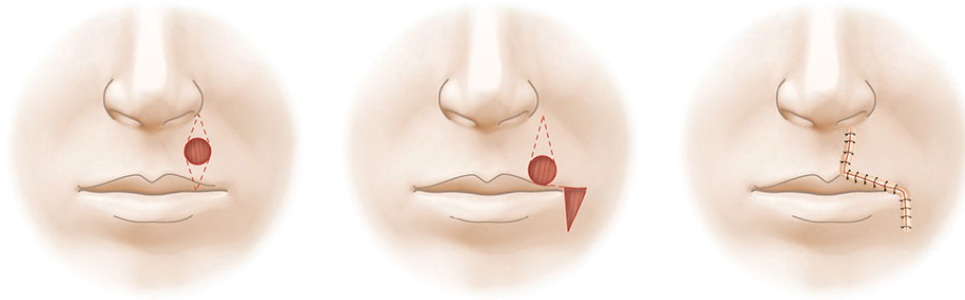


Figure 21-1. Advancement flaps allow for displacement of standing cones when they may infringe on free margins or cosmetic subunit junctions.

Common locations for advancement flaps include the upper and lower cutaneous lips, the nasal sidewall, the infraorbital cheek and lower eyelid, the forehead and temple, the preauricular cheek, and the helical rim. Advancement flaps have also been described for nasal tip defects (e.g., East–West flap).¹ However, the relatively immobile skin of the nasal tip and proximity to free margins limit the utility of advancement flaps to relatively small defects in this location.

Tension vectors

In contrast with rotation and transposition flaps, advancement flaps do not significantly alter the *direction* or *magnitude* of the primary tension vector for wound closure. The direction in which the flap slides toward the defect is considered the *primary* tissue motion, and the countermovement of the surrounding tissue to meet the flap is considered *secondary* tissue motion (Fig. 21-2). For defects of the midline face, the primary motion is usually lateral to medial; for defects of the lateral face, the primary motion is usually inferior to superior. Tension typically runs in a single vector along the direction of primary and secondary tissue motions, similar to what is seen with a linear closure.

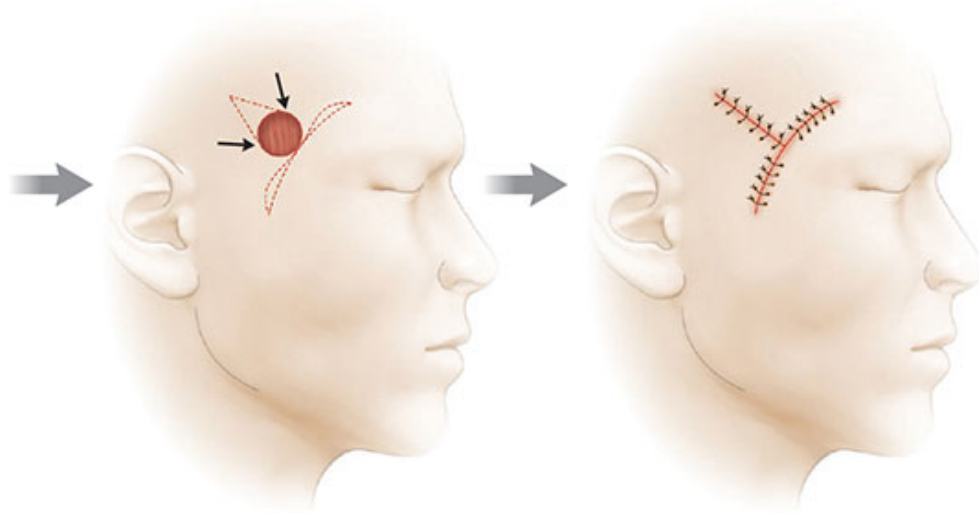


Figure 21-2. Closure with an advancement flap relies on the primary motion of the flap and the secondary motion of the surrounding tissue to meet the flap. Keeping the tension vector parallel to free margins helps to preserve their position.

The free margins of the eyelids, nose, lips, and ears are vulnerable to distortion from nearby advancement flaps.² To avoid distortion of the anatomic landmarks, advancement flaps are usually designed to orient tension vectors parallel to the free margins. However, in some cases, it is preferable to design a flap so that the main tension vector is oriented perpendicular to the free margin. Tacking sutures that anchor the undersurface of the flap to relatively immobile periosteum or the origins of underlying muscles may diminish or eliminate tension at the primary defect and prevent free-margin distortion. On the central face, superficial musculoaponeurotic system (SMAS) plication sutures may also decrease tension at the dermal edges of the primary defect.

The primary motion of the flap faces resistance from three main extrinsic forces: lateral restraint (whose vector runs opposite to the direction of primary motion), deep restraint from the host bed, and superior/inferior restraint of the adjoining skin tissue (Fig. 21-3).⁹ Lateral restraint causes the greatest restriction, and is dependent on the elasticity and mobility of the donor skin. Deep restraint from the host bed is the next most restrictive, and can be largely mitigated by undermining. Superior/inferior restraint is the least restrictive force, and may be diminished by extending the length of the flap as long as perfusion pressure remains intact. For a full discussion of flap dynamics, see [Chapter 20](#).

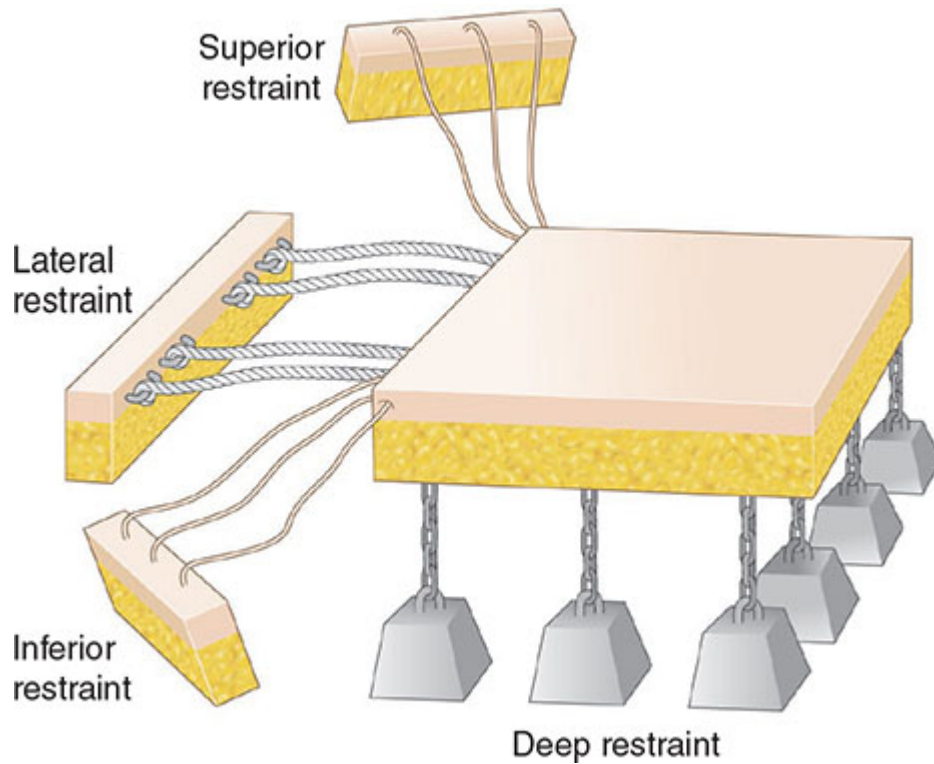


Figure 21-3. The resistance to flap advancement comes from three main extrinsic forces: lateral, deep, and superior/inferior restraint. Among these factors, lateral restraint directed 180 degrees away from the direction of flap advancement is of the greatest significance. Undermining largely mitigates deep restraint.

Standing cones

The standing cones (dog ears) created by an advancement flap may be handled in several ways. While the entire standing cone is often moved laterally in one or two directions (Figs. 21-4A and 25-4B), sometimes a portion of the standing cone is removed at the base of the flap, in a fashion similar to a partial linear closure. A small standing cone or a portion of a large standing cone can be “sewn out” using the rule of halves along the base of the flap (Figs. 21-4C and 25-4D). Alternatively, the standing cone may be removed in a crescentic fashion (Fig. 21-4E),³ especially along curved cosmetic subunit junctions, such as the vermillion cutaneous junction and the nasolabial fold/alar groove.

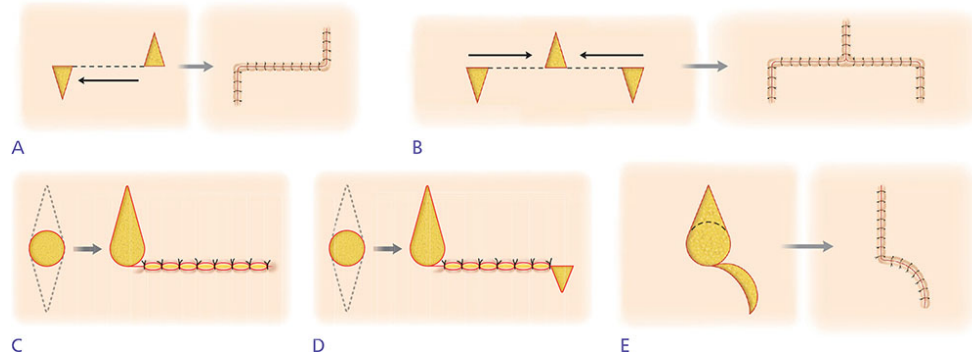


Figure 21-4. Several common methods exist to deal with the displaced standing cones. The entire standing cone may be moved laterally in one direction (A) or split in two directions (B). Alternately, “rule of halves” suturing may be used to handle the standing cone (C), or “rule of halves” suturing may be combined with excision of part of the standing cone (D). Finally, the standing cone can be handled with a crescentic excision (E).

Flap vascularity

As discussed in detail in [Chapter 20](#), flap survival depends on a reliable blood supply. The perfusion of blood through the vascular plexuses decreases as the distance from the feeding artery or arteriole increases. When the perfusion pressure is too weak to keep blood vessels patent, blood flow stops and necrosis ensues. The portions of an advancement flap most vulnerable to necrosis are the distal tip (since it has fewer blood vessels to nourish it and since it is most distant from the feeding artery or arteriole) and the portion of the flap sutured under the greatest tension (since the tension from the closure also results in compressive forces on blood vessels).

The ratio of the length of the flap to the width of its pedicle has a significant impact on perfusion. As a general guideline, random pattern flaps on the face can easily sustain a 3:1 length-to-width ratio, while those on the trunk and extremities may be best designed with a 2:1 ratio.^{4,5} These guidelines, however, are not absolute, as the robust facial blood supply may sustain flaps of significantly greater length-to-width ratios. Indeed, many flaps on the eyelid and helical rim⁶ are regularly executed with length-to-width ratios of 4:1 or greater. Moreover, at some point increasing the width of the flap pedicle fails to improve blood supply, as perfusion pressure may be insufficient to feed an excessively long flap.⁷

The anatomic plane of flap elevation also impacts the flap's vascular supply. Deeper undermining planes may incorporate larger caliber arteries with greater perfusion pressures, encouraging perfusion, though this must be weighed against the risk of damaging critical anatomic structures, such as branches of the facial nerve.

Ideal undermining planes for advancement flaps vary by anatomic location.⁸ For the majority of advancement flaps on the lateral face, the preferred anatomic plane is just above the SMAS, as this protects facial motor nerves, creates a flap of sufficient thickness to have a robust vascular pedicle, and permits clean and efficient flap elevation deep to the dermal and subcutaneous vascular plexuses (Fig. 21-5). On the central forehead, nose, and scalp, a sub-SMAS plane is usually preferred due to the relatively avascular nature of this tissue plane and the low risk for clinically relevant facial muscle weakness from cutting terminal motor nerve branches.

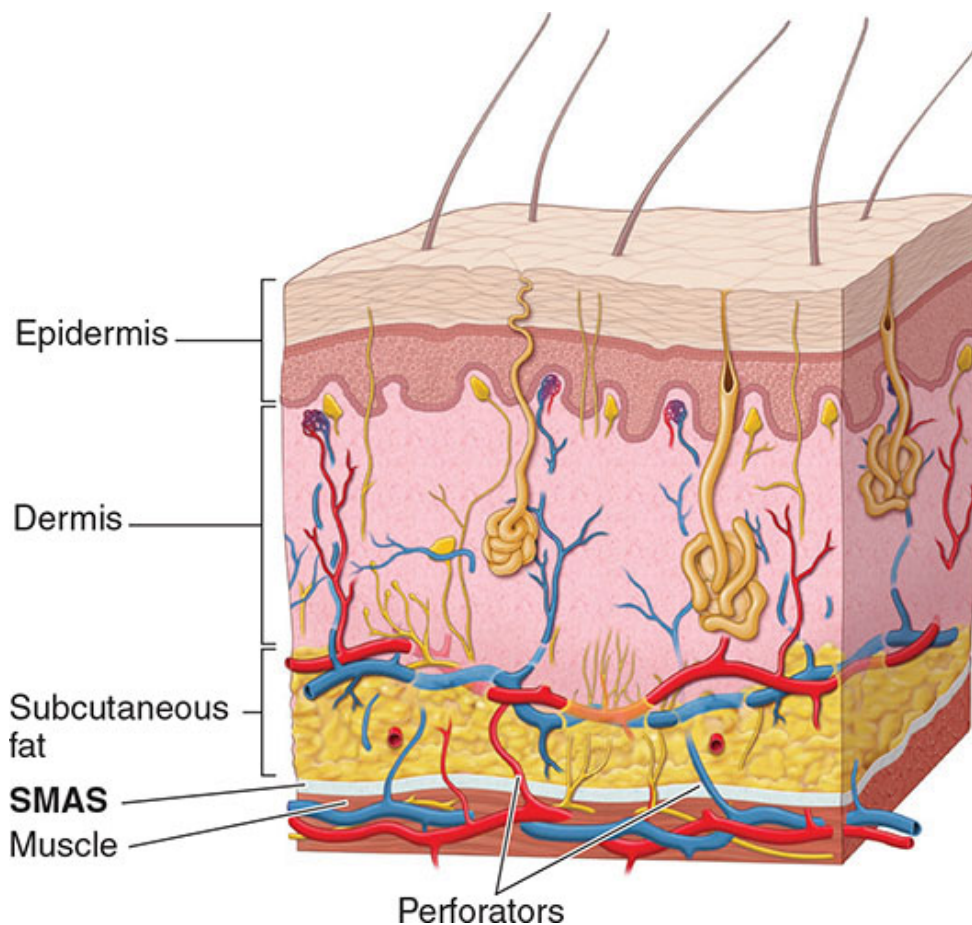


Figure 21-5. On the lateral face and neck, an undermining plane above the superficial musculoaponeurotic system (SMAS) preserves maximal flap vascularity while protecting facial motor nerves branches, which lie underneath the SMAS and innervate muscles from their lateral undersurface.

Wide flap undermining may decrease deep restraint, though it also may impair the blood supply by cutting vertically oriented perforating blood vessels that nourish the flap. Undermining should be performed carefully from the flap tip toward the pedicle only up to the point where sufficient movement is achieved. Additional undermining does not necessarily improve flap mobility because it does not influence the dominant restricting force of lateral restraint.⁹ Studies of tissue biomechanics have confirmed that wide undermining of advancement flaps does not add mechanical advantage or increase flap mobility.¹⁰

Altering the defect to optimize flap design and execution

Deepening the defect

When closing defects that arise after Mohs surgery, an initial consideration is whether the surgeon should deepen the defect to a uniform anatomic depth. Excision of tissue at the wound base often removes some obstructive restraint for wound closure, thereby facilitating wound-edge approximation. However, if deepening the defect may also risk functional deficit (i.e., facial nerve paralysis), it should be avoided. Deepening the defect to a uniform depth that corresponds to the anatomic plane for undermining facilitates efficient surgery and ensures that the tissue that “slides” into the wound matches the thickness of the defect.

Enlarging defects to camouflage the scar in cosmetic subunit junctions

While not always necessary or preferred, excising tissue between the surgical defect and a nearby cosmetic subunit junction may be helpful in

certain situations. Placing scar lines along cosmetic subunit junctions camouflages scars by hiding them in natural creases and shadows.^{11–13}

On the upper cutaneous lip, relaxed skin tension lines run radially from the vermilion–cutaneous junction, and horizontal scars in the middle of the subunit may be conspicuous. Extending a defect from the middle of the lateral cutaneous upper lip to the vermilion helps to hide the base of the advancement flap in the vermilion–cutaneous junction (Fig. 21-6). In contrast, on the forehead, the surgeon has several options to make incisions along cosmetic subunit junctions or along relaxed skin tension lines. The surgeon may opt to slide the flap along the relaxed skin tension lines (Fig. 21-7), the hairline, or the eyebrow. Wounds on the nasal sidewall may be extended inferiorly to hide the base of the advancement flap in the alar groove. The benefits of adhering to the subunit principle should be weighed against the sacrifice of healthy tissue and the creation of a larger defect requiring reconstruction.



Figure 21-6. Defect on the right upper cutaneous lip after Mohs surgery for a squamous cell carcinoma in situ. An advancement flap was designed. The remainder of the lip cosmetic subunit between the inferior margin of the defect and the vermilion–cutaneous junction was marked for removal to camouflage the scar along the vermilion–cutaneous junction (A). The 8-week postoperative result is shown (B).



Figure 21-7. Long-term result from a bilateral advancement with incisions along the horizontal relaxed skin tension lines on the forehead. Repair performed by an outside surgeon.

Suturing technique considerations

Unlike certain other local flaps, such as island pedicle flaps and bilobed flaps, advancement flaps are rarely associated with postoperative pin-cushioning. Moreover, the straight limbs of an advancement flap are often easier to camouflage along cosmetic subunit junctions. The surgeon should be careful to avoid hypereverting scars that are to be camouflaged in concave cosmetic subunit junctions, such as the nasolabial fold, as hypereversion of these areas may be associated with residual ridging. The base of an advancement flap is generally under minimal to no tension, so undesirable eversion in this location may take longer to settle (Fig. 21-8). To mitigate this

risk, suturing techniques may be adjusted accordingly, and simple buried sutures (that may encourage slight inversion) may be used in lieu of everting techniques such as the set-back suture or buried vertical mattress suture. If needed, suspension sutures or inverting techniques may be used as well; for a full discussion of tailored suturing approaches, see [Chapter 13](#).

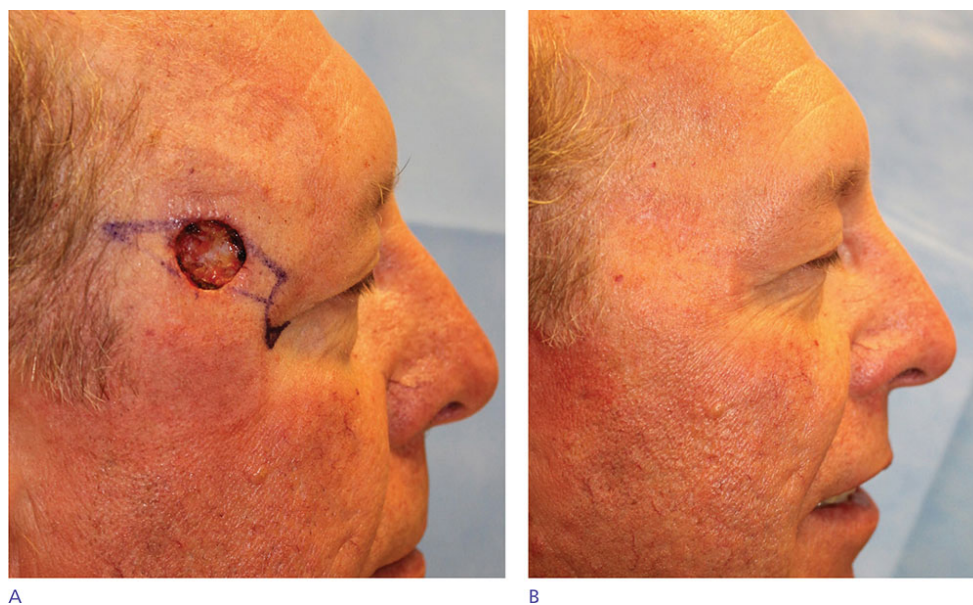


Figure 21-8. An advancement flap was used to reconstruct this defect on the lateral suprabrow (A). The incision line used to displace the standing cone is typically under minimal tension. Eversion along this line was persistent at 8 months postoperatively and can take substantial time to resolve spontaneously (B).

Anchoring procedures and SMAS plication for periocular flaps

The lower eyelid is vulnerable to ectropion from vertical tension, even if the defect does not directly involve the eyelid margin.² To avoid eyelid malposition, the lower eyelid may be anchored to the periosteum of the lateral orbital rim for support (Fig. 21-9). Laterally based suspension sutures in periocular reconstruction advance the tissue around the eyelid defect to the lateral orbital rim.¹⁴ SMAS plication may be occasionally helpful to avoid eyelid malposition and counteract the weight of a flap or gravitational pull for periocular advancement flaps.¹⁵ The degree of SMAS lift may be as small as a lateral suborbicularis oculi fat (SOOF) elevation or as large as a

modified lateral midface lift, depending on the size of the defect and the individual patient's anatomy. When performed, these techniques are often executed in concert with a canthoplasty.



Figure 21-9. Defect photo (A) after resection of a tumor on the lateral canthus and lower eyelid. The wound was repaired with an O-to-T advancement flap (B). To prevent downward traction on the eyelid, an external canthoplasty and a SMAS lift were performed to elevate the midface and prevent eyelid retraction (B). The patient had excellent apposition between the globe and the lower eyelid postoperatively (C).

Preoperative preparation and patient counseling

It is most accurate to mark the position of cosmetic subunit junctions *prior* to infiltrating local anesthesia. Distortion from anesthesia may blur these anatomic boundaries and make accurate placement of incision lines more challenging. While drawing these preoperative markings, it is helpful to explain to the patient why lines are being drawn that extend away from the site of the defect. This may also assist with controlling patient anxiety.

As with any closure, setting realistic expectations prior to advancement flap closure may help maintain a healthy patient–physician relationship in the postsurgical healing period. Beyond the typical counseling for infection, bruising, swelling, and scar formation, several situations may warrant extra counseling. First, advancement flaps on the lower eyelid are occasionally complicated by prolonged postoperative edema that may take months to fully resolve. Second, incision lines that fall along natural grooves or creases camouflage well over time, but they may be noticeable in the early postoperative period, particularly if the wound edges are markedly everted. In general, tincture of time and the occasional use of intralesional steroids correct any residual eversion.

TYPES OF ADVANCEMENT FLAPS

Advancement flap may be categorized based on the number and locations of standing cones that are displaced due to tissue advancement. Thus, with two standing cones on the sides of the defect and (in a simplified example) two directions to move the standing cones, four potential basic advancement flap designs are available. Additionally, the crescentic advancement flap is a frequently utilized approach in dermatologic surgery as well.

Burow's wedge flap (O-to-L)

The O-to-L advancement flap, also known as a unilateral Burow's wedge flap, is perhaps the most common variant of advancement flaps used by dermatologic surgeons (Fig. 21-10). Here, one standing cone is moved laterally along the base of the flap. Common locations for this flap are the cutaneous lip, the nasal sidewall, the forehead, the suprabrow, the temple, the lower eyelid, and the mid cheek (Fig. 21-11). A step-by-step approach to this flap technique is demonstrated in Figure 21-12 .

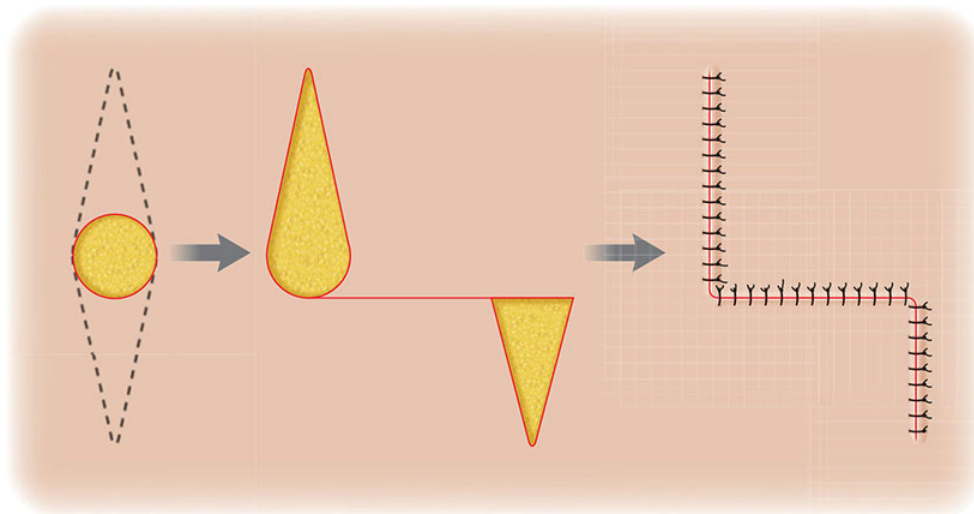
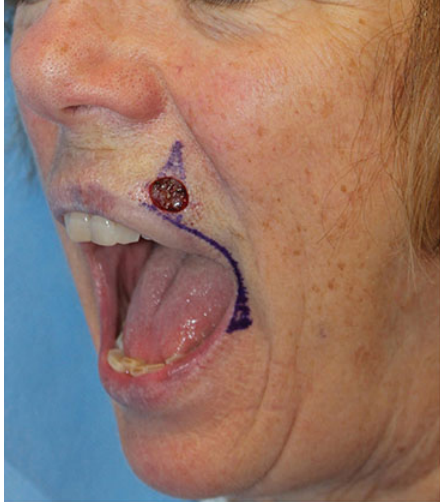


Figure 21-10. O-to-L flap design (Burow's wedge flap). Unidirectional primary tissue movement and one standing cone displaced.



A



B



C



D



Figure 21-11. Common locations for an O-to-L advancement flap are the cutaneous lip (A—defect; B—9-month follow-up), the nasal sidewall (C—defect; D—2-month follow-up), the forehead (E—defect; F—5-week follow-up), and the lower eyelid (G—defect; H—9-month follow-up).



A



B



C



D



E



F



Figure 21-12. Flap design (A). The inferior standing cone was removed (B,C,D). Then the incision along the junction of the cheek and eyelid was performed (E), and the flap was undermined above the SMAS (F). The skin around the defect was undermined (G). The first key suture was placed at the

point of the highest tension (H,I,J). The remainder of the deep (K) and superficial sutures are placed, and the patient is instructed to open his mouth widely, open his eyes, and look up to place the lower lid under maximal stress and assess for ectropion (K). Six-week follow-up image is shown (L).

A-to-T flap

A frequently used technique, also known as an O-T advancement flap, the A-to-T advancement flap splits one standing cone into two smaller cones along the base of the flap (Figure 21-13). Often, the standing cone is at least partially sewn out by a “rule of halves” suturing technique (see Chapter 19) that may obviate the need for large displaced dog ears. This approach is frequently used on the forehead and lips. A step-by-step approach to this technique on a Mohs defect on the right upper lip, right philtral column, and nasal sill is shown in Figure 21-14.

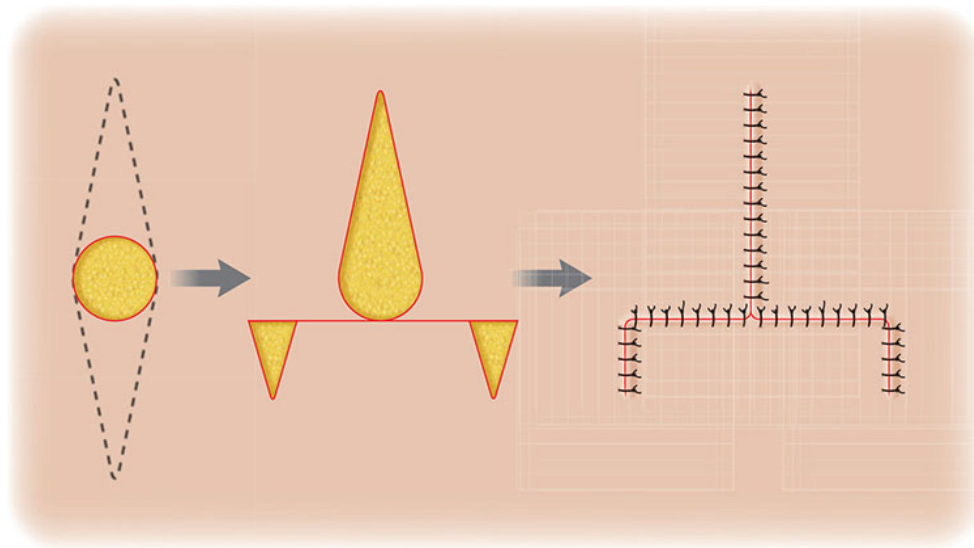


Figure 21-13. O-to-T flap design. Bidirectional primary tissue movement and one standing cone displaced.

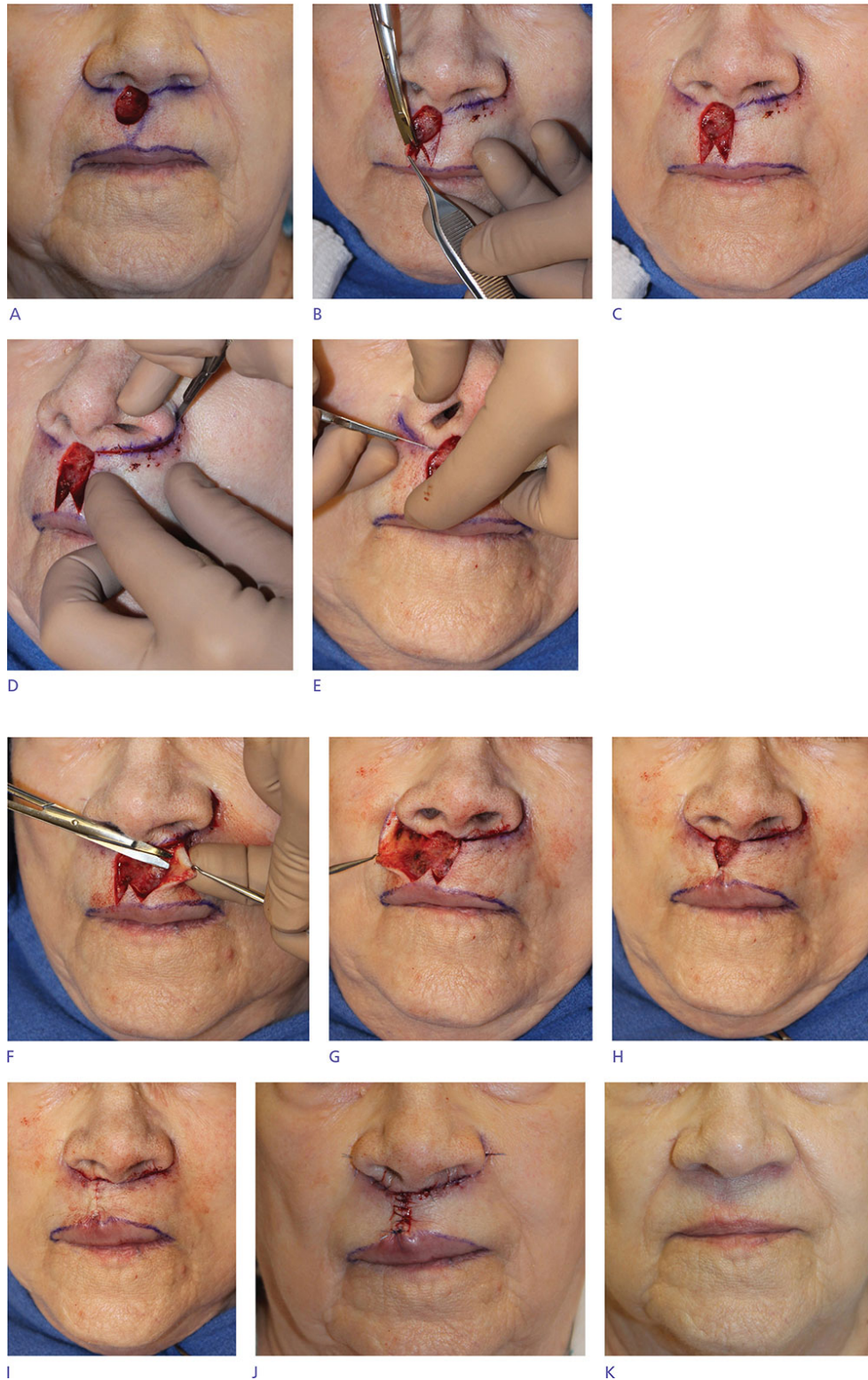


Figure 21-14. Defect after tumor removal (A). An O-to-T advancement flap with an M-plasty was designed to close the defect. First, the standing cones for the M-plasty were removed (B,C). The apices of the M-plasty were placed to either side of the peak of the vermillion-cutaneous junction below the

right philtral column (C). The incisions for the advancement flaps were made along the nasal sill (D,E), and the flaps were undermined above the SMAS overlying the orbicularis oris (F,G). The wound was then closed in a layered fashion (H,I,J), and her 3-month postoperative result with preservation of free-margin position is shown (K).

Unilateral advancement flap (O-to-U)

This classic unilateral advancement flap is often used for eyebrow defects, eyelid defects, and forehead defects (Fig. 21-15). The principal disadvantage of this advancement flap design is that the advancing edge of the flap may be quite distant from the vascular pedicle, depending on the degree of undermining. However, if the vascular supply is robust, successful results can be achieved even with high length-to-width ratios.

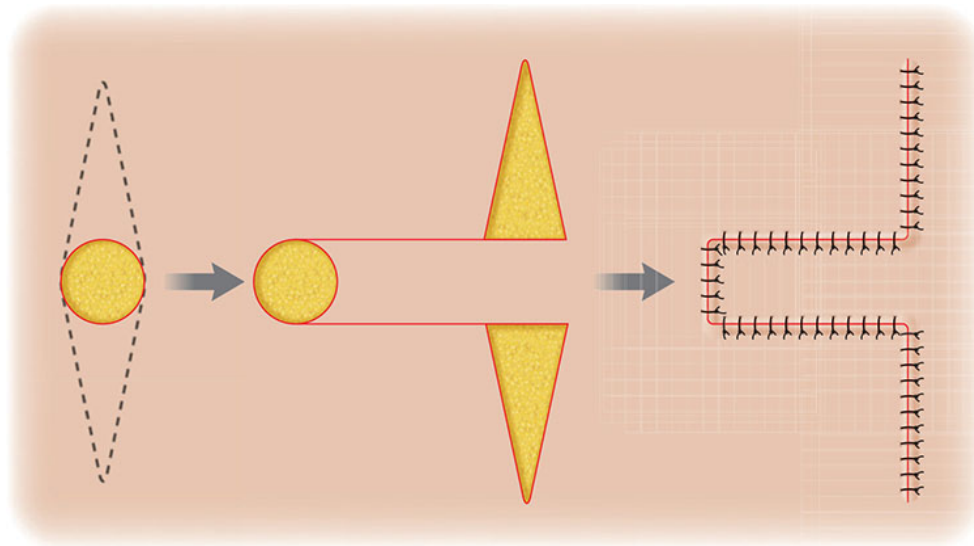


Figure 21-15. O-to-U flap design. Unidirectional primary tissue movement and two standing cones displaced.

A common variation of this approach is the helical rim advancement flap (Figs. 25-16 and 25-17). This technique is useful for even fairly large defects on the helix, and the robust blood supply available to this flap has been described.⁶

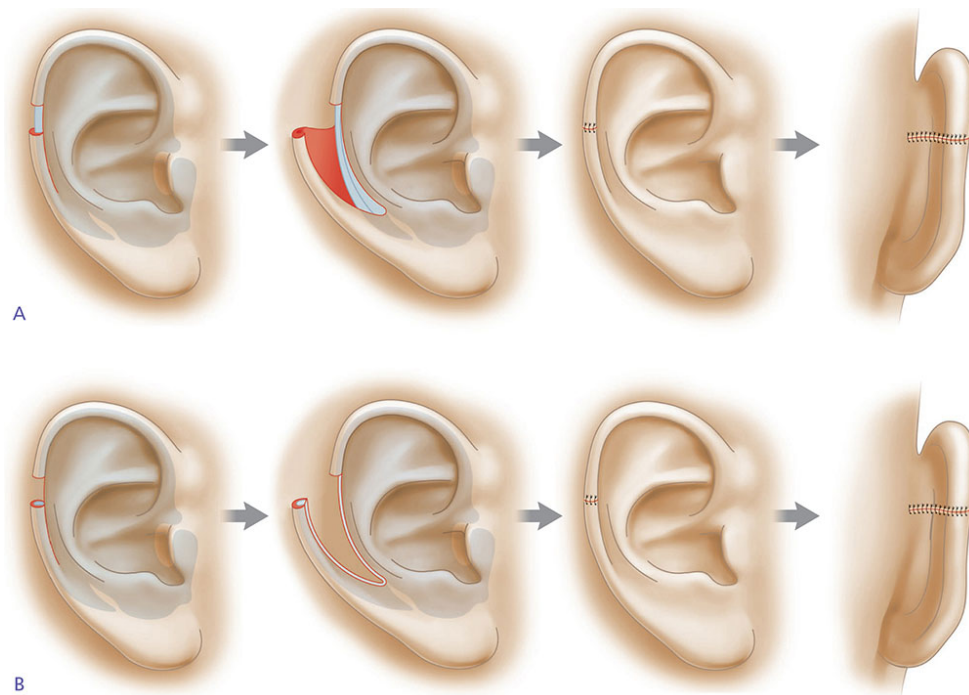


Figure 21-16. Schematic of helical rim advancement. **A.** A typical helical rim advancement flap. An incision is created along the anterior surface of the ear and carried into the lobule where a medial standing tissue cone is removed. The tissue is reflected off the cartilage and maintained on a posterior pedicle. The flap is advanced and the helical rim is approximated with eversion. A standing tissue cone is removed on the posterior surface of the ear. **B.** A chondrocutaneous advancement flap. Incision is carried out through cartilage and the flap is advanced and rotated into place. The inclusion of cartilage may be of greater benefit when the defect is higher on the helix or when more cartilage has been lost in the operative wound.



Figure 21-17. Defect and advancement flap design (A,B) with full-thickness incision planned through the helical rim for reconstruction. The 4-week postoperative result is shown (C,D).

The classic unilateral advancement flap may also be used in areas that are not traditionally approached with this technique, such as the cutaneous lip (Fig. 21-18).

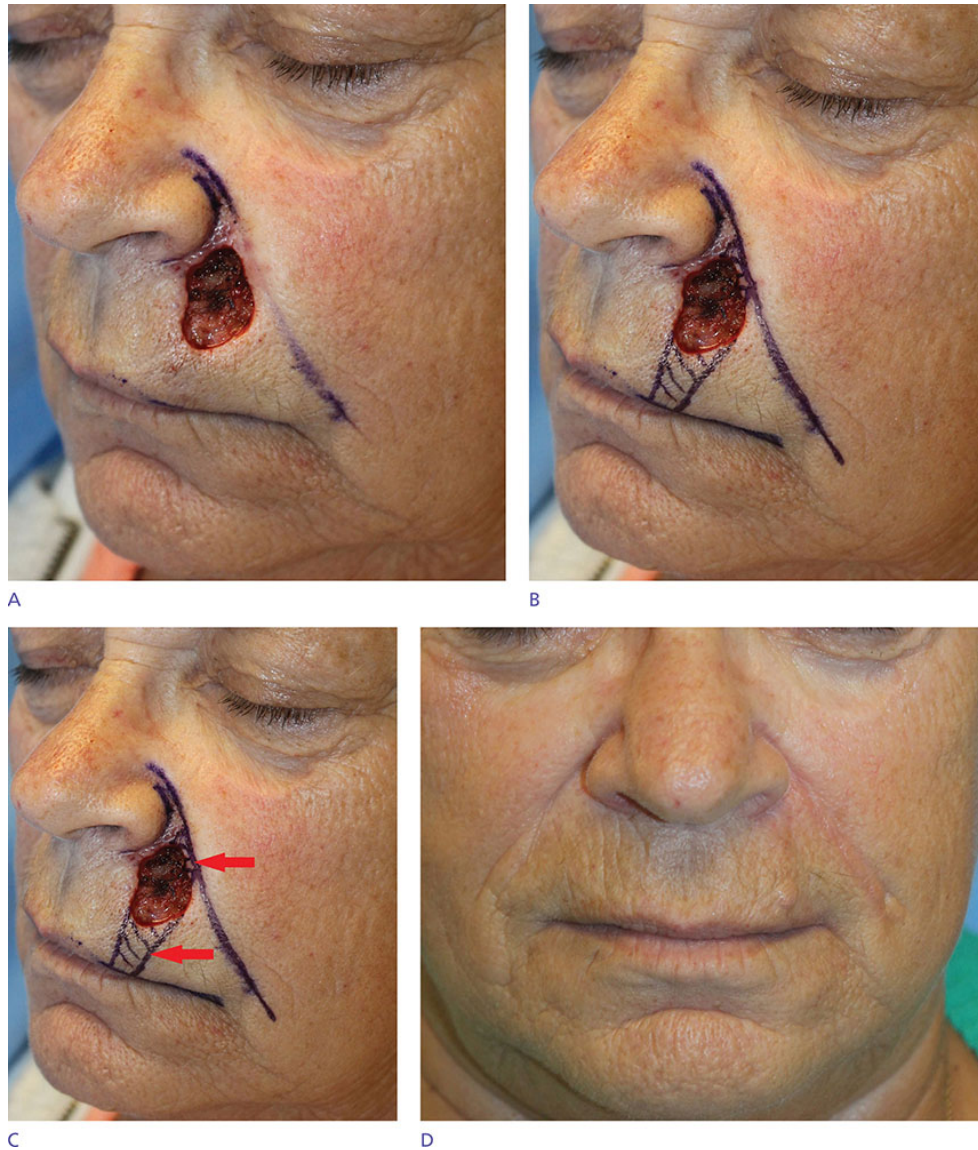


Figure 21-18. A defect on the left upper cutaneous lip resulted from removal of a squamous cell carcinoma with Mohs surgery (A). An O-to-U type advancement flap was designed with planned resection of the remainder of the lip cosmetic subunit (*red arrows*) between the nasolabial fold and the vermilion–cutaneous junction (B,C). Result at 2-week postop (D).

Bilateral advancement flap (O-to-H)

The bilateral advancement flap, also known as an H-plasty, is formed by creating two opposing O-to-U unilateral advancement flaps (Fig. 21-19). The result is an H-shaped scar that is ideally masked within relaxed skin tension lines or along cosmetic subunit junctions. Prior to making incisions for the second pedicle of the flap, it may be prudent to completely undermine and

mobilize the first pedicle to assess if the second arm is absolutely necessary. The two arms of the flap may be sized differently depending on the degree and location of required tissue movement.

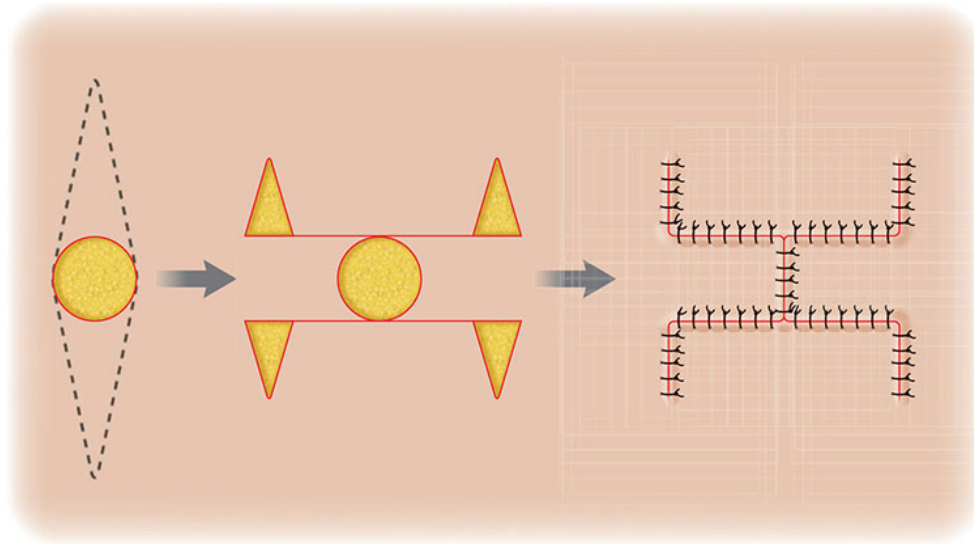


Figure 21-19. Bilateral advancement flap O-to-H design. Bidirectional primary tissue movement is seen and two standing cones are displaced.

Crescentic advancement flap

The crescentic advancement flap is a simple, yet powerful, variation of a unilateral advancement flap. Traditionally used along the alar crease and nasofacial sulcus, this technique is frequently employed for modestly sized nasal sidewall defects. This permits the surgeon to effectively hide incision lines in cosmetic subunit boundaries, and—importantly—as the curved crescents of tissue lengthen, this approach may obviate the need for dog-ear removal as well (Fig. 21-20).

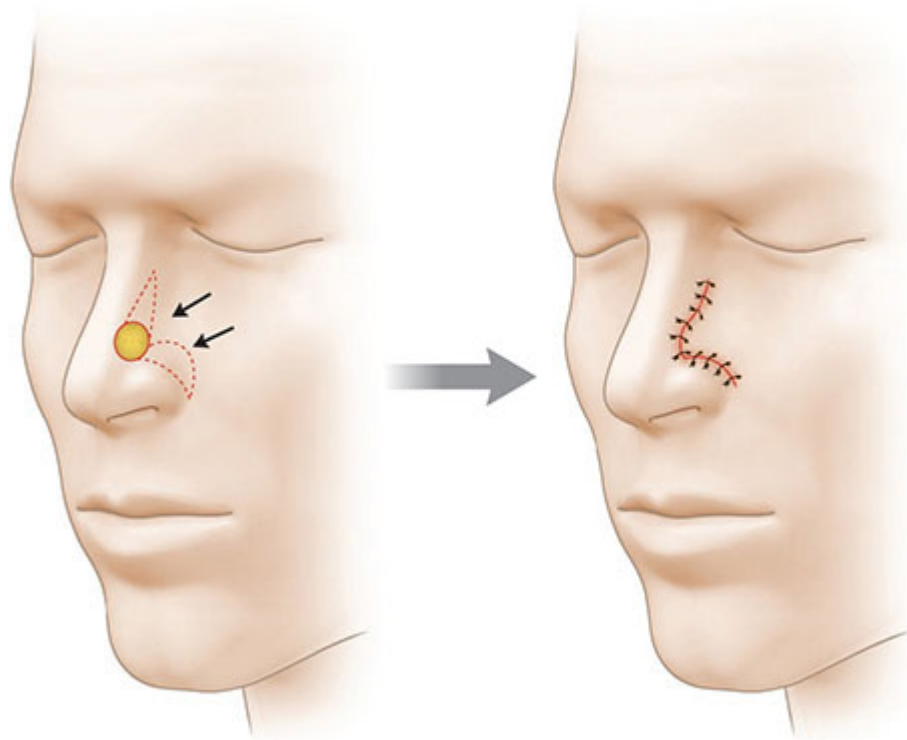


Figure 21-20. A crescentic advancement flap is designed to close an operative wound adjacent to the nasal ala with the upper and lower limbs of the advancement falling along the nasofacial sulcus, alar crease, and nasolabial fold. The design is simple in appearance but deceptively complex. As the flap advances, the shorter crescentic limbs stretch out to meet their destination and dog ears are not produced. Crescentic modification of a bilateral advancement flap may avoid the need for the removal of standing tissue cones.

COMBINING ADVANCEMENT FLAPS WITH OTHER CLOSURES

Advancement flaps may be used in isolation or in conjunction with other closure types. Combinations of repair types are typically employed when a defect spans multiple cosmetic subunits or when complete wound closure with an advancement flap would place excessive tension on the leading edge of the flap. Advancement flaps may be combined with skin grafts (Fig. 21-21) as well as secondary intention healing (Fig. 21-22), and SMAS lifts (Fig. 21-23).

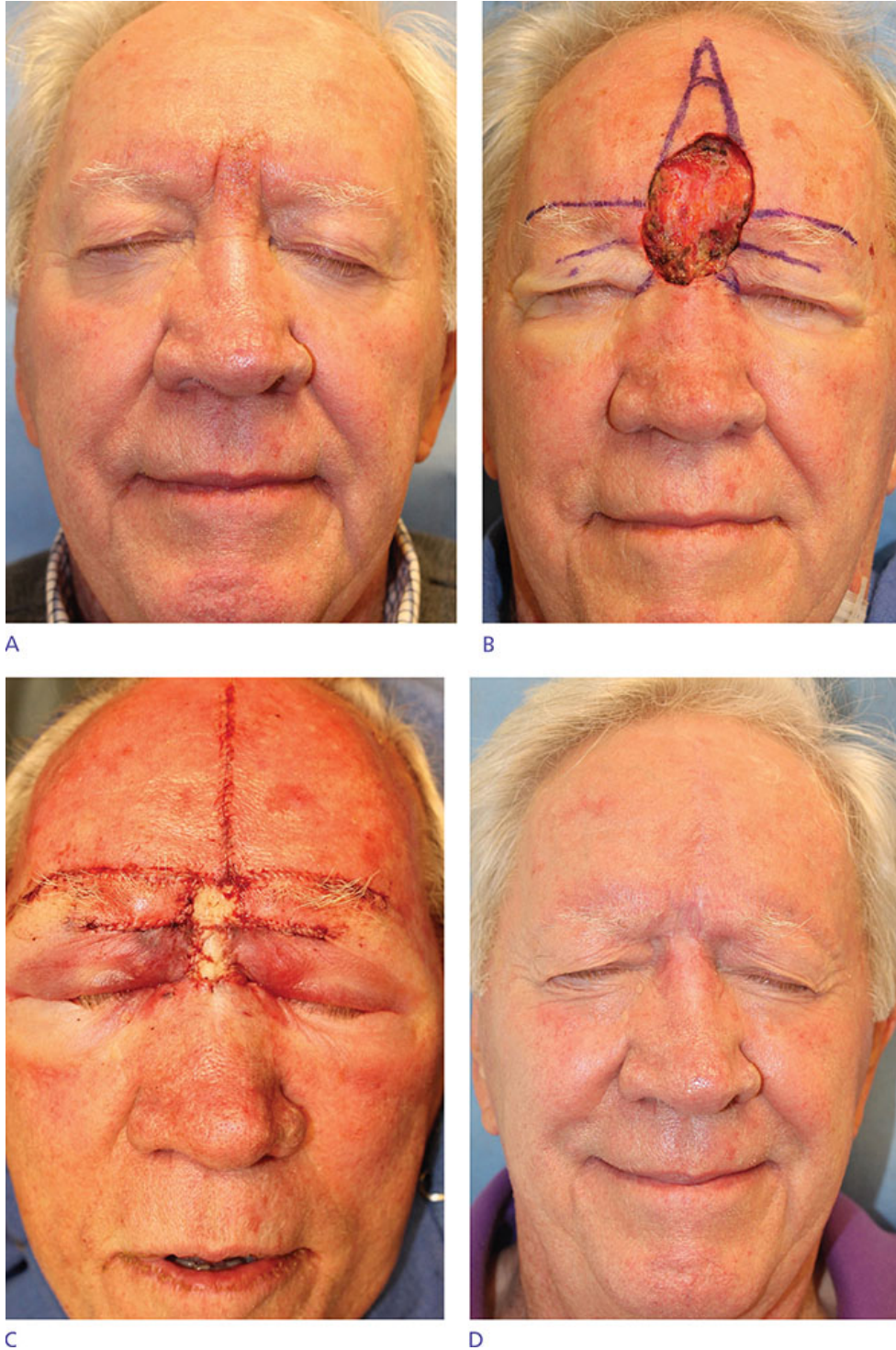


Figure 21-21. Clinical presentation of an invasive melanoma initially diagnosed as recalcitrant seborrheic dermatitis (A). Defect after removal with Mohs surgery with MART-1 immunostaining and closure design (B). Partial closure with bilateral advancement flap and repair of central glabella with a full-thickness skin graft (Burow's graft) to prevent medial eyebrow pull (C). Seven-month postoperative result (D).



Figure 21-22. Defect after two stages of Mohs surgery to remove an infiltrative basal cell carcinoma (A). Design of O-T type advancement flap along the nasal sill (B). Wound sutured closed with a small portion within the nasal cavity left to heal by secondary intention (C). The apical triangles were preserved. Three-month postoperative result (D).

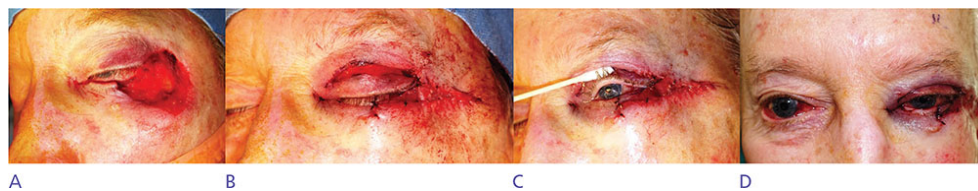


Figure 21-23. A lateral canthal defect involving 30% of the upper eyelid and 50% of the lower eyelid (A). A tarsal conjunctival flap from the upper eyelid was sutured in place to form the posterior lamella

(B). The anterior lamella was re-created using a direct advancement flap which was anchored to periosteum, and a SMAS lift was performed (C). The patient had good eyelid contour and position immediately after closure (D).

COMPLICATIONS

Lower eyelid edema

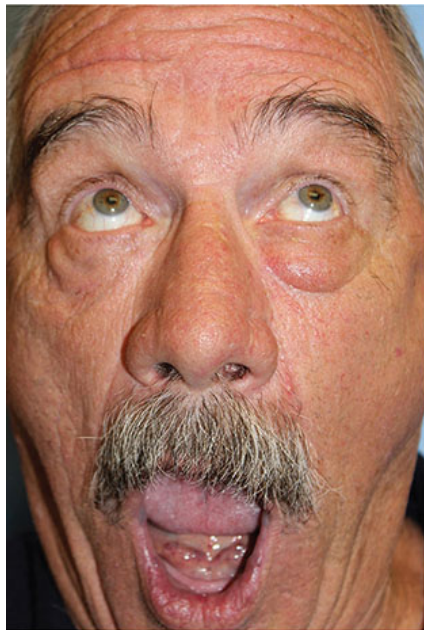
Edema of the lower eyelid is frequently seen after advancement flaps are performed on the eyelids and upper cheeks (Fig. 21-24). Warning patients of this eventuality may help mitigate anxiety and distress in the postoperative period, especially as this process generally resolves spontaneously over a period of months.



A



B



C

Figure 21-24. Defect after removal of basal cell carcinoma on the medial cheek and lower eyelid after two stages of Mohs surgery (A). The wound was reconstructed with an O-to-L type advancement flap, and no immediate postoperative ectropion was present even with the patient placing stress on the anterior lamella by opening his eyes and mouth (B). At 10 weeks, he continued to have lower eyelid edema (C). This resolved spontaneously over the following 3 months, and he declined further in-office follow-up.

Disruption of cosmetic subunit junctions

A cheek-to-nose flap may bridge the concavity of the nasofacial sulcus as the wound contracts, unless the flap length is adjusted accordingly and tacking sutures are used to recreate the concavity. While this may be corrected with a secondary procedure, it is far better to appropriately design the flap *de novo* and utilize an appropriate-sized flap with tacking sutures, saving the patient the significant morbidity and cost associated with a secondary procedure.

On the lip, advancement flaps that require excision of the superior standing cone along the base of the nose may ablate the apical triangle and divert the nasolabial fold toward the lateral ala.^{16,17} If there is no alternative to preserve the apical triangle, patients should be counseled preoperatively that the nasolabial fold may appear to “dive into” the nasal sill as opposed to continuing seamlessly onto the nasal sidewall. The natural course of the nasolabial fold can be restored with a Z-plasty.

Displacement of free margins

Whenever an advancement flap is adjacent to a free margin, the surgeon must be careful to keep from “pulling” or “pushing” the margin out of position. To avoid “pulling” on a free margin, the primary tension vector for closure should be parallel to the free margin. “Pushing” may occur when the opposing sides of the advancement flap that come into apposition are significantly longer than the length of the original tissue that is being resurfaced, similar to the phenomenon that occurs with fusiform linear closures.¹⁸

Postoperative complications such as edema, bleeding, or tension can cause ectropion of the lower eyelid. Late ectropion is typically secondary to poorly designed flaps that “pull” on the lower eyelid (e.g., the tension vector for wound closure has a component that is oriented perpendicular to the eyelid margin), scar contraction, or insufficient replacement of the anterior lamella with an undersized graft or flap. Skin grafts and canthal tightening procedures are often used to repair ectropion. Intraoperative assessment of lower eyelid position may help to avoid ectropion. The surgeon can ask patients to open the mouth widely, open the eyes widely, and look up, a position that maximizes stress on the anterior lamella of the lower eyelid (Fig. 21-24). As edema secondary to local anesthesia may temporarily alter free-margin position during surgery, careful preanesthesia planning is of paramount importance.

Advancement flaps from the cheek for defects on the nasal dorsum or sidewall are a reliable option for reconstruction (Fig. 21-25). However, for defects that extend below the peak of the alar groove, advancement flaps from the cheek may result in superior displacement of the nasal tip and alar rim. For these defects, other reconstructive options should be considered to avoid free-margin displacement.



Figure 21-25. Defect with inferior edge above the peak of the alar groove (A). Advancement flap designed (B). Four-month postoperative result with preservation of the position of the alar rim (C).

“Bulldozing,” or the appearance of downward displacement of the lateral portion vermilion cutaneous junction (white line), may occur when an advancement flap along the white line does not account for the difference in the vertical position of the medial white line compared to the lateral white line (Fig. 21-26). Especially in patients with a larger slope to their vermilion–cutaneous junction (usually younger patients and women), an ill-planned advancement flap may bulldoze the vermilion inferiorly (Fig. 21-27). Anticipating this eventuality, a small wedge can be removed at the vermilion–cutaneous junction prior to closure, avoiding the need for a secondary revision procedure.

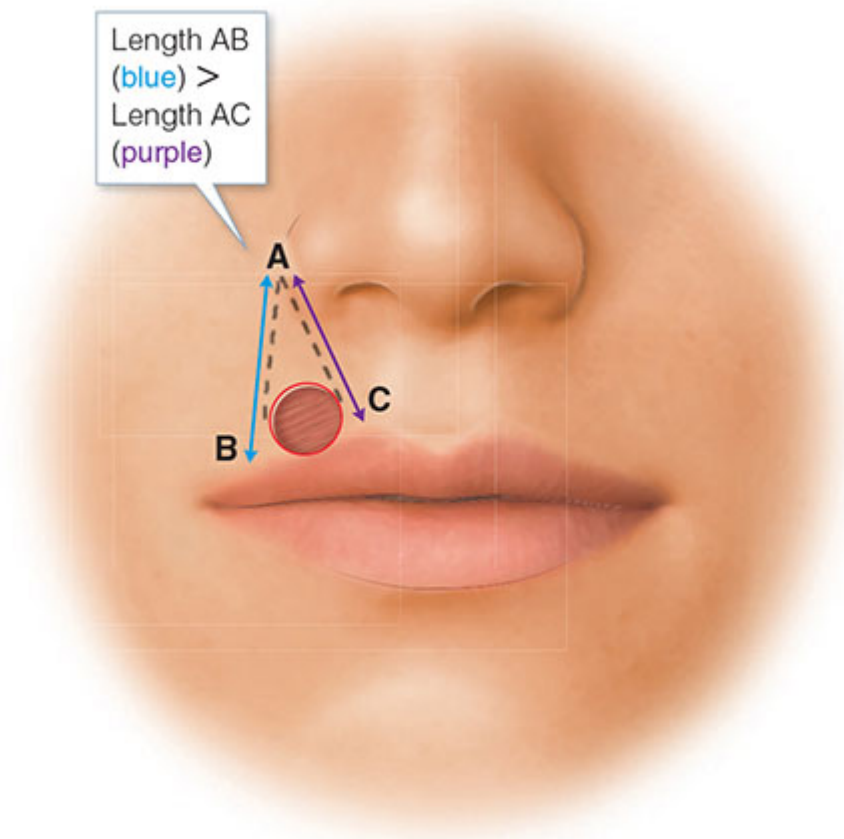


Figure 21-26. The geometry of upper lip bulldozing. The discrepancy between the vertical position of the medial white line compared to the lateral white line may lead to downward displacement of the lip.



Figure 21-27. Defect after removal of a basal cell carcinoma with two stages of Mohs surgery in a 31-year-old female. Note the relatively steep slope of her vermilion–cutaneous junction (A). Immediate postoperative appearance after advancement flap closure (B). Postoperative appearance at 5 months with “bulldozing” or “hooding” of the right lateral vermilion lip by the advanced tissue (C).

Textural differences

When an advancement flap is utilized to repair a defect, the advanced tissue typically has an excellent color and texture match to the native skin.

However, for defects bridging cosmetic subunits, advancement flaps may fill the defect with skin of a different texture, hair density, or thickness. In such cases, it may be helpful to thin the dermal component of the flap to match the thickness of the skin surrounding the defect.

CONCLUSIONS

Advancement flaps represent a versatile workhorse reconstructive approach, particularly for defects close to free margins. Appropriate design and execution require mastery of several key concepts, including appreciating the direction of the primary tension vector; handling the displaced standing cones; balancing local factors that impact flap vascularity; and deciding when to alter the defect prior to tissue advancement. Thoughtful incorporation of these concepts, while keeping in mind the fundamental principles of flap dynamics, results in predictably reliable outcomes.

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CHAPTER 22 Rotation Flaps

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SUMMARY

- Rotation flaps recruit tissue via rotational movement around a pivot point and rely on tissue laxity adjacent to the surgical defect.
- Tension vectors can be dispersed variably across the arcuate path of the flap, and there are two areas where tissue redundancy becomes evident—the pivot point adjacent to the primary defect and the flap base at the end of the arcuate incision.

Beginner Pearls



- Pivot point redundancy can be removed as a standing cone either before (“triangulating” the defect) or after inset of the flap; flap-base redundancy can be redistributed by meticulous rule-of-halves suturing or removed as a standing cone.
- All rotation flaps are subject to rotational shortening and pivotal restraint—as the flap tip rotates inward to fill the primary defect, the arc length of the flap decreases, which can be solved by oversizing the flap.

Expert Pearls



- A backcut can further reduce pivotal restraint and assist in rotating the flap into place, though it also reduces the width of the pedicle and may compromise flap perfusion.
- Rotation flaps may be very useful on the nose; always keep in mind that the undermining plane should be submuscular.

Don't Forget!



- A double rotation flap comprising two traditional rotation flaps taking off from the opposite sides of the defect can be useful in areas of high tension.
- The comet (or dog-ear rotation) flap combines a primary closure of one end of the defect with the creation of a rotation flap from the tissue redundancy at the other end of the defect, and is particularly useful on the cheek.

Pitfalls and Cautions



- Large cheek flaps may result in ectropion; this risk may be reduced by using suspension sutures and oversizing the flap.
- Other complications include persistent lower eyelid edema and textural mismatch.
- The long secondary defects created by rotation flaps may lead to secondary tissue movement and free-margin compromise.

Patient Education Points



- Patients should be warned prior to flap closure that they will have an incision stretching well beyond the initially visible defect.
- Explaining that the additional scar length will likely heal with a minimally visible line may go a long way toward patient reassurance.

Billing Pearls



- Flap repair codes (140XX series) include the excision component, so it is not appropriate to bill both an excision and a flap repair code simultaneously.
- Mohs codes may be submitted along with flap repair codes, though they may be subject to the multiple- procedure reduction rule.
- When coding a flap, medical necessity is the ultimate arbiter of appropriateness.

CHAPTER 22 Rotation Flaps

INTRODUCTION

Rotation flaps are local cutaneous flaps that rely on tissue laxity adjacent to the surgical defect in order to accomplish closure. By design, these flaps recruit tissue via rotational movement around a pivot point. Rotation flaps are overwhelmingly random pattern flaps deriving blood supply from the dermal and subdermal plexuses, although on occasion they may carry axial vessels within the flap body.

In its most basic form, a rotation flap is created by extending a curvilinear or arcuate incision from the defect around a central pivot point. Inherent in this design is the formation of a broad pedicle and a desirable length-to-width ratio. These features contribute to reliable vascularity, viability, and an overall robust flap.

Rotation flaps differ from primary repairs or advancement flaps by the orientation of tension vectors. In primary repairs or advancement flaps, the tension vectors generally are directed perpendicular to the long axis across the wound, whereas in a rotation flap, the tension vectors can be dispersed variably across the arcuate path of the flap.

Rotation flaps in dermatologic surgery were first described by Konz and colleagues in 1975 for the repair of facial defects, but the use of rotation flaps dates back to 1842 as reported by Pancoast in the early plastic surgery literature.^{1,2} Since then, rotation flaps have been widely used in reconstructive surgery, and have been used for a variety of disease processes including pilonidal sinuses, decubitus ulcers, and cicatricial alopecia.³⁻⁵ In dermatologic surgery, rotation flaps have become a cornerstone of reconstruction, and their utility extends well beyond that of classically described rotation flaps with known eponyms.

FLAP DYNAMICS AND DESIGN

As with the design of any flap, it must first be determined which tissue reservoir will be recruited. A rotation flap is, by definition, a sliding flap. The tissue reservoir must be immediately adjacent to the defined surgical defect. When choosing a tissue reservoir, cosmetic subunits and potential distortion of free margins must be taken into consideration. Once the most appropriate reservoir has been identified, a curvilinear arc is extended from the wound around a central pivot point. Ideally, this arcuate incision may lie within a relaxed skin tension line, though this is not always possible. After the flap is incised, the flap, primary, and secondary defects are all widely undermined. The flap can then be rotated inward to fill the primary defect (Fig. 22-1).

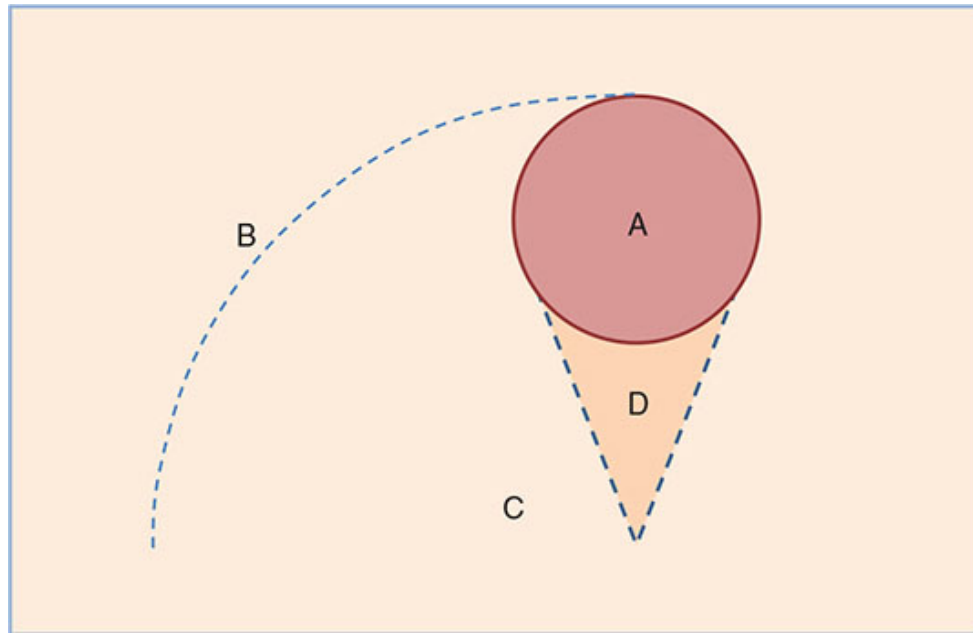


Figure 22-1. Rotation flap geometry. (A) The primary surgical defect is denoted by the red circle. After determination of the tissue recruitment area, a sweeping curvilinear arc is carried away from the primary defect with a tangential start point (B) around a central pivot point (C). Tissue redundancy can be anticipated adjacent to the pivot (D), and oftentimes is removed preemptively as a standing cone.

At this point, there are two areas where tissue redundancy becomes evident—the pivot point adjacent to the primary defect and the flap base at the end of the arcuate incision. Pivot point redundancy can be removed as a standing cone either before (“triangulating” the defect) or after the inset of

the flap, and flap base redundancy oftentimes can be redistributed by meticulous “rule-of-halves” suturing or removed as a standing cone. This redundancy may or may not be significant, depending on the site and size of the defect.

A critical consideration in flap design is sizing of the flap. All rotation flaps are subject to rotational shortening and pivotal restraint—as the flap tip rotates inward to fill the primary defect, the arc length of the flap decreases. This is due to tissue restraint at the flap base. In clinical practice, two basic designs create the initial construct for most rotation flaps. These designs primarily differ in arc length of the flap tip and takeoff point. The arc of rotation for a standard rotation flap classically begins tangentially to the defect. With the forces of pivotal restraint, the flap tip is shortened upon rotation into the defect, and the tip must be advanced upward to completely fill the gap. As a result, a degree of tension is transferred to the flap tip, already the area most susceptible to necrosis. To combat this design flaw, Dzubow described a vertical offset or a “step-up” of the takeoff point of the flap.¹ In other words, this modification extends the length of the leading edge of the flap past the surgical defect, and can be thought of as “oversizing” the flap (Fig. 22-2). This approach allows the rotation flap to fill the defect under minimal tension on the flap tip. However, increasing the length of the leading edge of the flap will result in a larger secondary defect, which may be undesirable depending on the cosmetic subunit. This, in turn, will increase the tension across the secondary defect and must be accounted for. This exchange of tension between the two designs was nicely demonstrated by Lichon et al. *in vivo* using pig models and tension-measuring devices.²

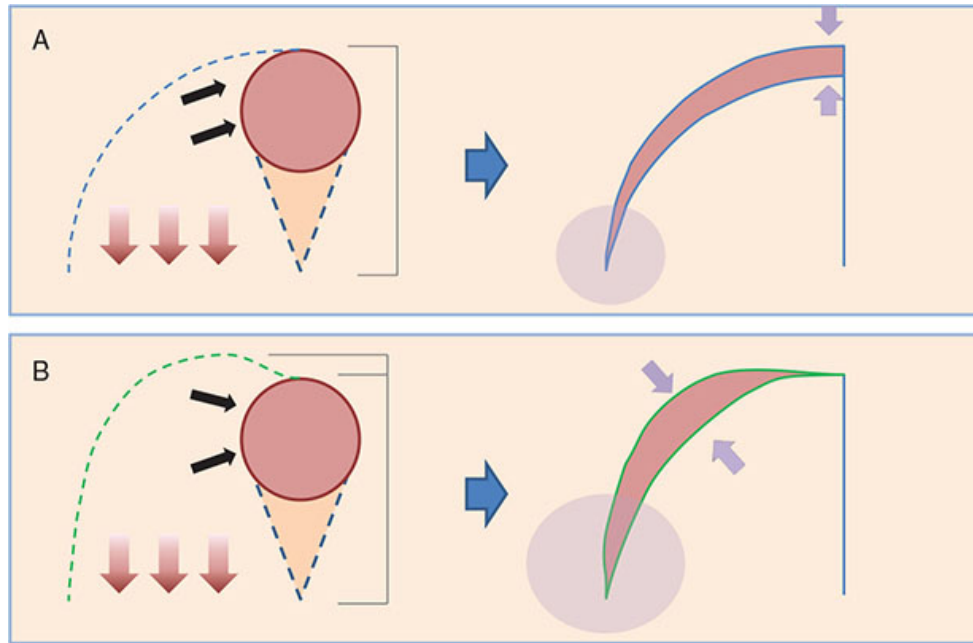


Figure 22-2. Rotational shortening. (A) Rotation flap designed with “traditional” tangential takeoff angle. Pivotal restraint effectively shortens the flap tip as it moves through the arc of rotation, and places additional tension on the tip once the flap movement is complete. (B) Oversized rotation flap design overcomes rotational shortening but creates a larger secondary defect and potentially creates more tissue redundancy. Black arrows, primary flap movement; red arrows, vector of pivotal restraint; purple arrows, the greatest area of tension on secondary defect; purple circles, potential tissue redundancy.

Additional modifications to rotation flap features can aid in tissue movement and redirect tension vectors. The use of a backcut can further reduce pivotal restraint and assist in rotating the flap into place (Fig. 22-3). However, careful attention must be paid to the length of a backcut that is utilized. A backcut inherently reduces the width of the pedicle and may compromise flap perfusion. The overall length of the arc of the rotation flap is also a key component. Specifically, the arc length of rotation is inversely proportional to the closure tension across the secondary defect. This concept must not be overlooked when free margins are in close approximation of the planned secondary defect. Finally, the total angle of rotation should be considered. *In vivo* studies have shown that generally 90 to 135 degrees of rotation is appropriate. More obtuse angles of rotation do not improve, and may in fact hinder, tissue movement.³

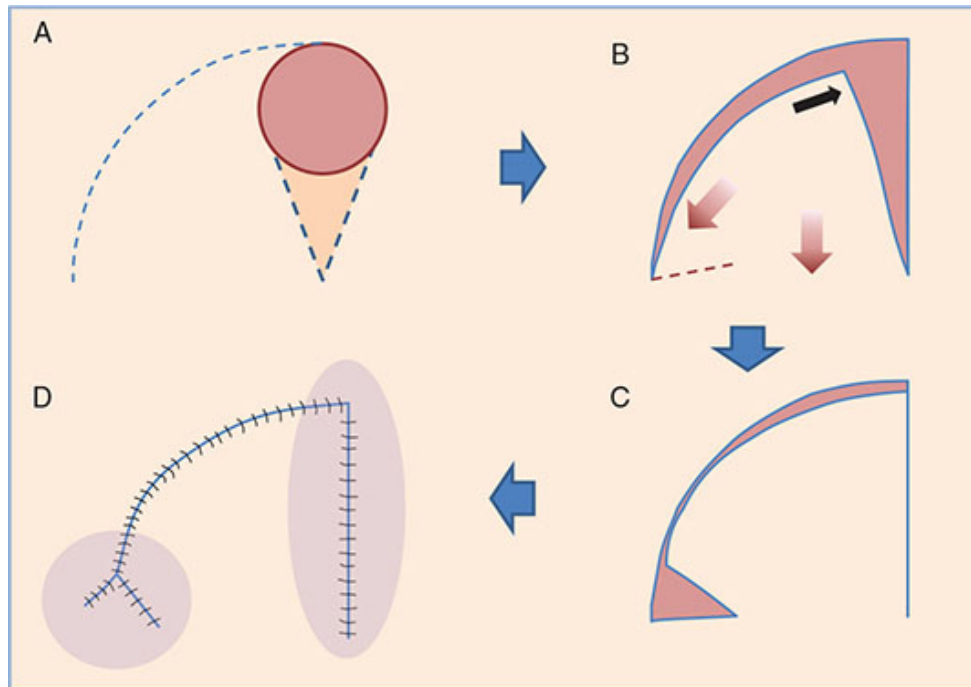


Figure 22-3. Backcut modification. (A) A standard rotation flap is designed, but occasionally excess laxity is needed to complete the rotation. (B) A backcut is designed and incised. (C) This allows the completion of the rotation arc. (D) Final closure—the secondary defect of the backcut is closed in a V-Y fashion. Black arrow, primary flap movement; red arrows, tissue restraint vectors; purple circles, tension on final closure.

NOSE

Dorsal nasal rotation flap

In 1967, Rieger described the dorsal nasal rotation flap as a means for closing medium- to large-sized defects on the distal nose measuring up to 2 cm in diameter (Fig. 22-4).⁴ This flap utilizes tissue laxity on the upper nose and glabella. Marchac and Toth modified this flap by removing a standing cone vertically oriented from the superior aspect of the defect into the flap pedicle.^{5,6} Due to the rich blood supply of the flap, the authors argued that the flap was amenable to a shortened flap base in favor of greater mobility. Rigg described a variant of the dorsal nasal flap termed the heminasal flap that is particularly useful for smaller defects of the distal nose.⁷ The heminasal flap has the benefit of utilizing only a portion of the nasal skin. Depending on the location of the defect, the location of the free edge of the flap and the pedicle

can be adjusted. For example, the free edge of the flap would be oriented along the nasal midline for more medial defects, whereas lateral defects would be more readily repaired with the free edge directed along the nasofacial sulcus.

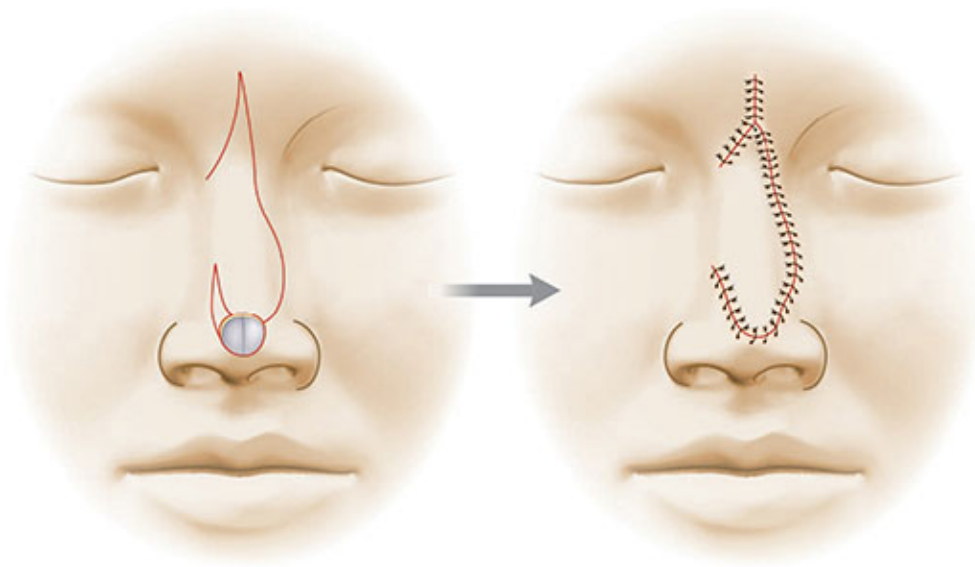


Figure 22-4. The dorsal nasal rotation flap. Note the use of a large backcut in the glabellar area to better mobilize the flap.

This flap and its modified versions are executed in a very similar fashion (Figs. 22-5 and 22-6). Initially, a broad sweeping incision is made from the glabella and carried downward past the medial canthus and along the nasofacial sulcus to the distal aspect of the defect. For purely midline defects, the pedicle may be based on either side of the nose. For defects that are even slightly lateral of midline, a contralateral pedicle is desired. A backcut of 30 to 45 degrees is made in the glabella to further aid in rotation. A general strategy for determining the height of the glabellar component of the flap is to measure 1.5 to 2 times the height of the nasal tip defect.⁸ The nasal component of the flap is then elevated just above the level of the periosteum and perichondrium. Undermining of the flap continues across the nasal dorsum to the contralateral nasofacial sulcus. When undermining the flap in the glabella, the level is superficial to procerus and corrugator supercilii muscles to prevent unnecessary disruption of motor function in this region. Once adequate hemostasis is obtained, the flap is rotated into place. The secondary defect in the glabella is typically closed first in a layered

fashion. As the flap is rotated, the glabellar portion of the flap usually becomes redundant and is trimmed. Careful planning and sizing of the flap as well as undermining of the surrounding tissue are necessary to prevent asymmetry. Oversizing of the flap is often utilized to prevent undesired distortion of the nasal tip. Additionally, a longer, broader arc of rotation can prevent pull on the contralateral medial canthus and ala.

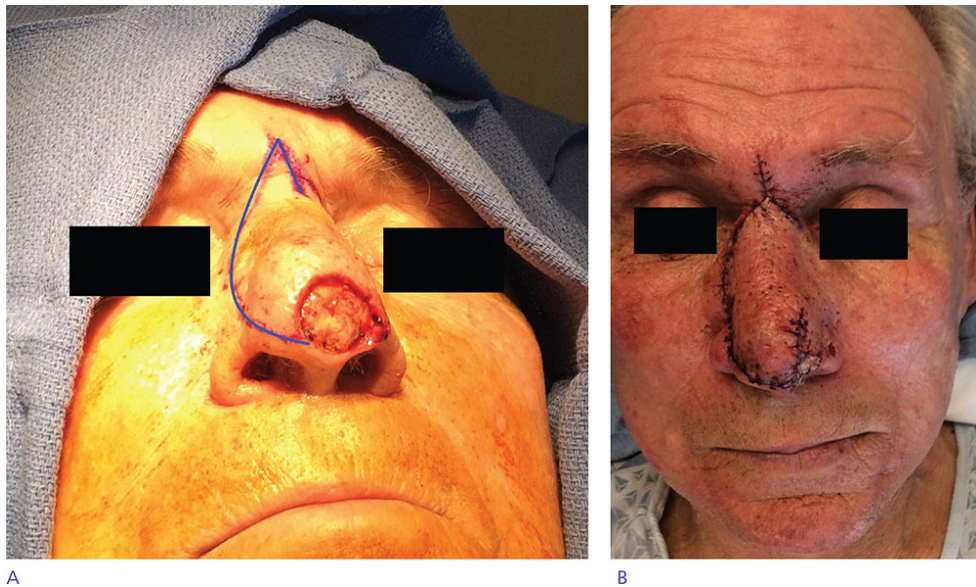


Figure 22-5. Dorsal nasal rotation flap (“Reiger flap”)—defect of right nasal tip and supratip greater than 1 cm. A sweeping incision designed along the nasal sidewall and extending to the glabella with a backcut. The flap is rotated inferomedially, and the trailing edge of the flap is closed in a V-Y fashion.



Figure 22-6. Heminasal variant of dorsal nasal rotation flap—this flap was limited to one-half of the nasal dorsum and sidewall, achieving significant tissue recruitment from the ipsilateral nose and glabella.

There are several advantages of the dorsal nasal rotation flap. First, it provides good local tissue match for both color and texture. This flap also generally respects cosmetic subunit boundaries. Most of the suture lines fall within the glabellar furrows, the nasofacial sulcus, and the alar creases. Additionally, the robust blood supply derived from angular artery perforators contributes to excellent flap viability. Finally, this flap has the benefit of being a single-staged repair.⁷ The primary disadvantage of this flap is its large size, as much of the skin of the nose must be elevated to achieve adequate tissue movement and coverage.

Other nasal rotation flaps

A variety of other rotation flaps add to the cache of repairs for nasal reconstruction. A traditional rotation flap can be very useful in small- to medium-sized defects on the distal nasal sidewall, particularly those located just superior to the alar crease (Figs. 22-7 and 22-8). For such defects, a laterally based rotation flap utilizes tissue laxity from the sidewall superolateral to the wound, while also orienting the resultant standing cone along the alar crease. Similarly, traditional rotation flaps can be used to repair small defects of the middle-third of the ala located just below the alar crease. From the defect, incising laterally and inferiorly along the alar crease creates a rotation flap that is confined to the alar subunit. Once rotated medially, it provides excellent tissue coverage and match without adversely affecting the free margin of the alar rim.



Figure 22-7. Rotation flap repair of the supra-alar nasal sidewall with good cosmetic outcome. Although not represented in this repair, it is paramount to consider distortion of the ipsilateral alar rim when designing an adjacent rotation flap.



Figure 22-8. Medially based rotation flap for a lateral nasal sidewall defect. The glabella provides an ample tissue reservoir in this scenario within limited potential for webbing of the medial canthus.

Similar to a traditional rotation flap from the nasal sidewall, Hafiji et al. described a laterally based rotation flap from the nasal sidewall as an alternative to a bilobed flap for the repair of lateral nasal tip defects. Coined the “advancement and inferior rotation of the nasal sidewall (AIRNS)” flap, it incorporates advancement from the medial canthal region and rotation from

the nasal sidewall to repair defects of just over 1 cm. It also has the benefit of directing the standing cone deformity nicely along the alar crease.⁹

The spiral flap is another rotation flap elevated from the nasal sidewall that, in addition to simple rotation, can be utilized to repair defects involving or just below the alar crease (Fig. 22-9). This flap utilizes the relatively narrow flap tip folded back upon itself allowing preservation of the alar crease. As described by Mahlberg et al., this flap is useful for reconstructing defects of the alar groove and alar body of 5 to 15 mm in diameter.¹⁰ Not only does this flap offer the benefits of a single-stage repair with excellent local tissue color and texture match, it also reliably recreates the alar groove. Careful attention must be paid to preserving a broad pedicle, as there is a tendency when designing this flap to increase the length-to-width ratio which may predispose it to distal tip necrosis. This can be done by designing the flap as a logarithmic spiral as opposed to a classic Archimedean spiral.

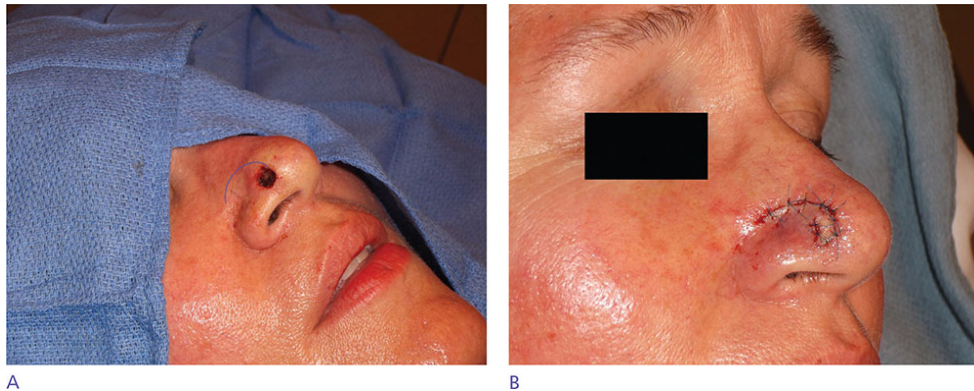


Figure 22-9. Spiral flap—the spiral flap is a useful repair option for small defects of the superior ala. The leading tip of the flap is folded upon itself, allowing for accurate recreation of the alar groove. Caution must be taken to avoid undue tension on the tip as it is particularly susceptible to necrosis and strangulation.

A novel medially based rotation flap was reported by Bryan et al. for small- to medium-sized defects of the middle-third of the alar crease. Dubbed the “wave” flap, it shares elements of both a medially based hemi-nasal rotation flap and the spiral flap. Like a medially based hemi-nasal flap, it touts a broad pedicle and practicality for lateral nasal defects. Yet, similar to the spiral flap, the distal tip is turned back onto itself and cosmetically recreates the alar crease. One benefit of this flap over the spiral flap is that

the majority of its incision lines are camouflaged within the nasofacial sulcus.¹¹

Similar to the spiral and “wave” flaps, the “shark” island pedicle flap also takes advantage of rotating a portion of the flap back on itself to help recreate the alar crease (Fig. 22-10). It is particularly useful in reconstructing combined alar and medial cheek defects. This flap can be thought of as having two distinct components. The trailing portion of the flap is very similar to a traditional V-to-Y island pedicle flap. It is a random pattern flap of a long triangular shape oriented along the nasolabial fold that derives its blood supply from perforators of the angular artery. To this traditional island pedicle flap, the shark flap adds a leading portion that extends around the defect both superiorly and proximally. This small isthmus is a myocutaneous flap incorporating fibers of the levator labii superioris and should be designed to be the same width as the alar portion of the defect. As the trailing portion of the flap is advanced and the secondary defect is closed behind it, the leading portion is rotated between 90 and 180 degrees back on itself. This creates an inverted standing cone and suture line that create the alar crease.¹²

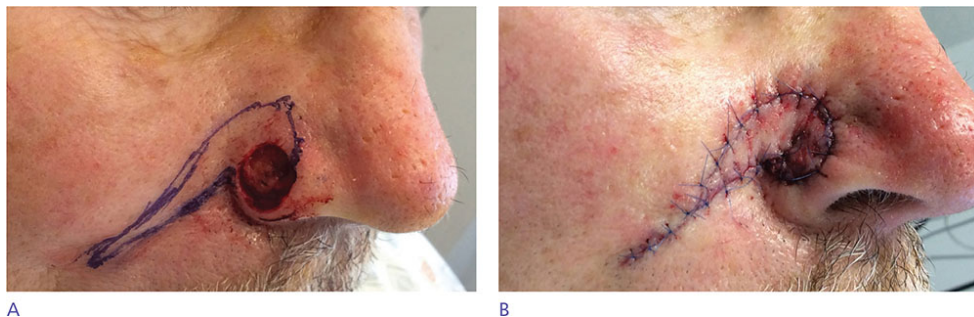


Figure 22-10. Shark-island flap—a variant on the spiral flap which recruits from the medial cheek and nasolabial fold. Again, tip necrosis is a concern, and measures to avoid excess tip tension are paramount to success.

The Peng flap, later modified by Rowe, is both a bilateral rotation flap and a direct advancement flap that recruits tissue from both nasal sidewalls and the glabella, respectively (Fig. 22-11). It is useful for nasal tip defects or defects straddling the cosmetic subunit boundary between the nasal tip and distal nasal dorsum of up to approximately 2 cm.^{13,14} Incisions are made from the medial canthus inferiorly along the nasofacial sulcus to the distal aspect

of the defect. The bilateral flap is then undermined and elevated deep to the nasalis muscle and then rotated medially to meet each other. A standing cone deformity is removed superiorly along the nasal dorsum. A more recent modification advocates for incising the distal portion of the flaps along the alar crease to better hide suture lines within subunit boundaries. Additionally, the cheeks can be advanced bilaterally to assist in the closure of the secondary defect with the removal of crescentic standing cone deformities along the alar crease as needed.¹⁵

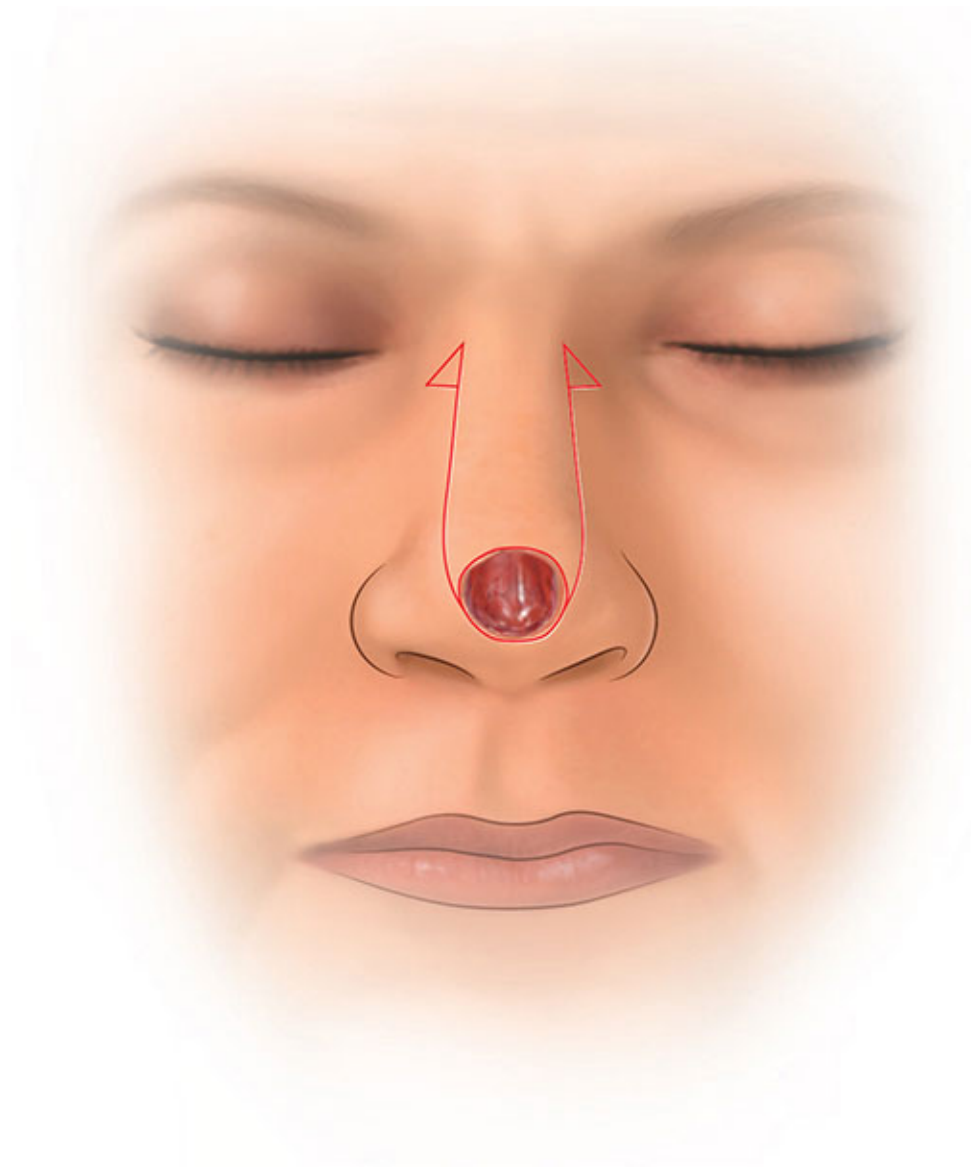


Figure 22-11. The Peng flap.

EYELID AND INFRAORBITAL REGION

Large rotation flaps recruiting tissue laxity from the temple and cheek have been used to close surgical defects of the lower eyelid for nearly a half century. In 1966, Mustarde initially described a large rotation flap where a long, sweeping incision is made laterally along the lower eyelid–cheek junction, coursing superolaterally onto the temple and then inferiorly along the preauricular cheek.¹⁶ Coined the “Mustarde flap,” this reconstructive option has proved to be useful for large defects of the medial cheek and lower eyelid (Fig. 22-12). In 1970, Tenzel described a semicircular rotation flap from the temple of similar design and movement. This flap also incorporated the orbicularis oculi muscle and was intended for repair of full-thickness defects of the central or lateral lower eyelid.¹⁷ The movement of the Tenzel flap is further aided by a lateral canthotomy and cantholysis. Wounds up to two-thirds of the width of the lower eyelid can be repaired with this method.



Figure 22-12. Classic cheek rotation “Mustarde” flap—this classically described rotation flap is useful in the repair of large medial lower eyelid and upper medial cheek defects. A long, sweeping incision along the inferior eyelid, and extensive undermining is performed. Immediate postoperative and long-term postoperative results are shown as well with excellent cosmetic results. Redundancy along the nasofacial groove usually requires removal as a standing cone. Postoperatively, eyelid edema and lack of sensation are common findings.

As with many other rotation flaps, both of these flaps utilize advancement in addition to the primary motion of rotation. The tension vector along the leading free edge of the flap is oriented medially, while tension on the trailing edge is directed superiorly and laterally toward the temple and preauricular cheek. Very little tension is directed inferiorly, minimizing undesired distortion of the free margin of the lower eyelid. As stated previously, the length of the arc of any rotation flap is inversely proportional to the tension across the secondary defect. The long incision lines of these flaps further ensure minimal tension across the secondary defect and mitigate

the potential for ectropion. However, Mustarde himself recognized that large rotation flaps from the cheek have a tendency to sag over time given the added tissue bulk carried forward onto the lower eyelid.¹⁸ He advocated for the use of both deep tacking sutures and septal cartilage grafts to support the lower eyelid.

Numerous modifications to these basic designs have been described. The use of a Z-plasty at the lateral aspect of these flaps has been advocated as a means to push them medially. This effectively serves to resist the natural tendency of the tissue to recoil laterally. Additionally, inverted forms of the semicircular flap have been shown to be useful in repairing similar defects of the upper eyelid.¹⁹ Rao and Frank described a modification of the Mustarde flap which is helpful for repair of medial eyelid defects. It incorporates the standing cone typically created inferior to the defect as a Burow's graft to repair the noneyelash-bearing margin medial to the lower lacrimal punctum.²⁰ Purely cutaneous defects of the lower eyelid are very amenable to repair with a modification of Tenzel's semicircular flap. The principle design and tissue movement are identical to the original flap and they still require a superior arcuate extension to avoid unwanted secondary motion of the eyelid inferiorly. However, this flap modification is cutaneous only, being elevated above the level of orbicularis oculi, whereas the flap was musculocutaneous in its initial description.

Large temple and cheek rotation flaps are not without shortcomings. As mentioned, the primary concern with these flaps is support of the lower eyelid and prevention of downward tension that may result in ectropion. Both oversizing of the flap with broad superolateral arcuate incisions and the use of suspension sutures helps combat this potential pitfall. The Mustarde flap particularly relies on laxity from the preauricular cheek. If this laxity is not present, unwanted tension may occur with rotation and predispose to distal flap necrosis.¹⁹ Additionally, long-lasting eyelid edema is common owing to the disruption of the local lymphatic system. Finally, textural mismatch of the thick skin of the cheek and the thinner skin of the eyelid can also present challenges. This may be compensated for with appropriate thinning of the flap edge and careful suturing technique.

SCALP

Rotation flaps are particularly well suited for reconstruction of defects of the scalp, as limited intrinsic tissue mobility is often encountered. Though traditional single-arm rotation flaps are adequate in many circumstances, at times the added tissue recruitment from additional opposing rotation flaps may be required. A double rotation flap comprised two traditional rotation flaps taking off from opposite sides of the defect can be useful in areas of high tension. The opposing flaps are undermined in the subgaleal plane and rotated toward each other but in the same clockwise direction around the wound. The advancing edges of the flaps then meet together in the center of the defect (Fig. 22-13).²¹ When sutured in place, the resultant incision lines form a “Z,” thus explaining its common moniker of an “O to Z flap.” Though used infrequently, triple rotation flaps are noted in the plastic surgery literature for reconstructing large scalp defects. Specifically, Bardach described a technique that incorporates three opposing rotation flaps with backcuts.²² In addition to repairing surgical defects, these flaps can be used to correct areas of cicatricial alopecia.²³ Regardless of which rotation flap is employed on the scalp, all offer several advantages. Recruitment of local hair-bearing skin provides excellent match in color, texture, and hair density, and these flaps are relatively easy to elevate owing to the bloodless subgaleal plane of dissection. The primary disadvantage of either a double or triple rotation flap is the sheer quantity of incision lines created. However, the cosmetic impact may be minimal in this location if hair can be used to conceal these lines.



Figure 22-13. O-to-Z rotation flap of the scalp—large defects of the scalp can be closed with opposing rotation flaps in a “Z” orientation. Repair shown with good results and minimal distortion of surrounding free margins.

CHIN

Both midline and lateral chin defects are very amenable to repair via rotation flaps. This, in large part, is due to the contour of the chin, specifically the downturned semicircular shape of the mental crease in many individuals. Single-armed, traditionally designed rotation flaps are particularly suited for laterally based defects on the chin. These flaps are elevated above the mentalis muscle, and the long arcuate incision line is camouflaged neatly within the mental crease. Defects ranging from 2 to 3 cm can be repaired with excellent cosmesis.²⁴ Midline chin defects near the mental crease may be more appropriately reconstructed with a double, bilateral rotation flap. Nearly mirror image flaps are designed, again with the arc of rotation hidden in the cosmetic boundary separating this area from the cutaneous lip. As opposed to the O to Z flap, in this area, bilaterally symmetric flaps are rotated in opposite clockwise directions. The leading edges of the flaps meet in the midline and sutured together. A standing cone deformity is formed immediately inferior to the defect and requires extirpation.

CHEEK

Given the excellent tissue mobility on the cheek, most small- and medium-sized wounds are readily repaired in a primary fashion. However, larger surgical defects or those located near anatomic free margins may benefit from repair with rotation flaps. Large wounds of the preauricular cheek or inferior temple can be nicely closed with broad, medially based rotation flaps utilizing tissue laxity from the lower cheek and neck ([Figs. 22-14 through 22-16](#)). These flaps are undermined at the level of the superficial subcutaneous fat. The use of a backcut can aid in the rotation of these flaps or a standing cone deformity can be removed posteriorly around the earlobe to add a component of advancement to their movement. One advantage of this design is that it conceals many of the incision lines along the hairline and within skin folds of the preauricular cheek.

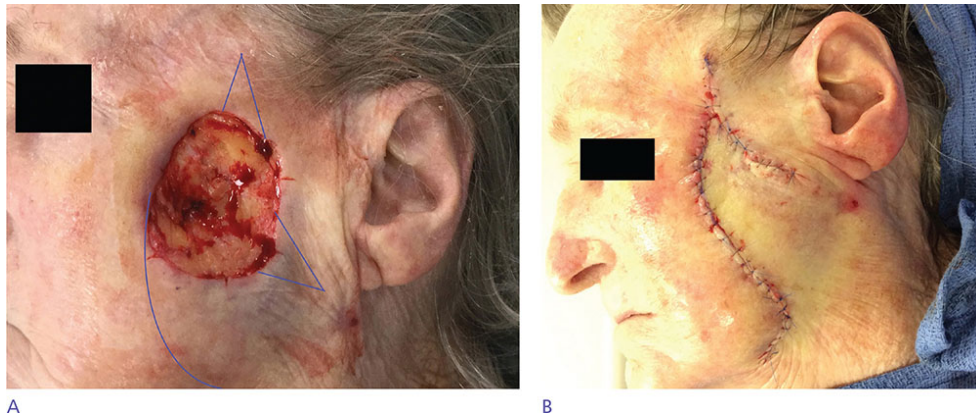


Figure 22-14. Rotation flap repair of a lateral cheek defect. Given the size of the defect, tissue recruitment from the ipsilateral jowl and submental skin is required. The defect size was narrowed first with a superior standing cone.



Figure 22-15. Large defect of the central cheek closed with a laterally based rotation flap. Note that the standing cone is oriented parallel to the nasolabial fold for optimal cosmesis.



Figure 22-16. Very large centromedial cheek defect. A large, laterally based rotation flap is designed to recruit from the lateral cheek, jowl, and submental skin. Once again, the inferior standing cone is

placed within the nasolabial fold to preserve the cosmetic subunit.

Defects on the superior cheek that are more medially located can be repaired with similarly designed inferolaterally based rotation flaps. Also undermined in the superficial subcutaneous fat, these flaps are rotated superiorly with the long arc of rotation oriented along the nasofacial sulcus. A flaw inherent in this design is the propensity to pull inferiorly on the lower eyelid and create a potential for ectropion. A recent small case series demonstrated that superomedial anchoring of such flaps to the periosteum of the nasal bone or medial maxilla resulted in no occurrences of ectropion.²⁵

The comet flap or dog-ear rotation flap, though useful in a variety of locations on the head and neck, is particularly useful on the cheek. This repair combines a primary closure of one end of the defect with the creation of a rotation flap from the tissue redundancy at the other end of the defect. After it is determined which end of the wound would be optimally closed in a primary fashion, the standing cone deformity is excised and an intermediate-layered closure is performed to a point at which further closure is not permitted due to excessive tension. The rotation flap is then designed to maximally utilize the tissue redundancy of the standing cone at the opposite end of the wound. The length of the arcuate incision of the flap should be approximately equal to the length of the remaining wound edge to provide for adequate rotation with minimal tension across the secondary defect.²⁶

LIP

Medium-sized defects of the upper cutaneous lip can be nicely reconstructed with a rotation flap elevated just medially to the nasolabial fold (Figs. 22-17 through 22-19). The long arc of rotation is incised along this cosmetic boundary separating the upper lip from the cheek, and the flap is then undermined above the orbicularis oris muscle. The incision line may be extended as far inferiorly as necessary to achieve adequate rotation without distortion of the commissure and vermillion. If required, a standing cone deformity angled medially can be removed around the commissure onto the lower cutaneous lip to prevent unwanted tissue movement. When rotated into position, a standing cone deformity must be removed inferior to defect. If the defect approaches or involves the apical triangle, the flap should be designed

and rotated in such a fashion as to recreate this important cosmetic subunit. Fullness of the upper lip and increased show of the vermillion are common in the immediate postoperative period, but this resolves within a week or two in an overwhelming majority of cases. A recent case report demonstrated excellent cosmetic outcomes for defects of 1 to 2 cm in diameter on the lateral upper cutaneous lip.²⁷



Figure 22-17. Defect of the right upper cutaneous lip–nasolabial fold repaired with a rotation flap. (A) Preoperative appearance. (B) Postoperative appearance.



Figure 22-18. Rotation flap of the lateral upper cutaneous lip (“Hatchet flap”). Note the rotation flap is designed such that the rotational arm of the flap recreates the nasolabial folds and the standing cone lines within the vertical perioral furrows.

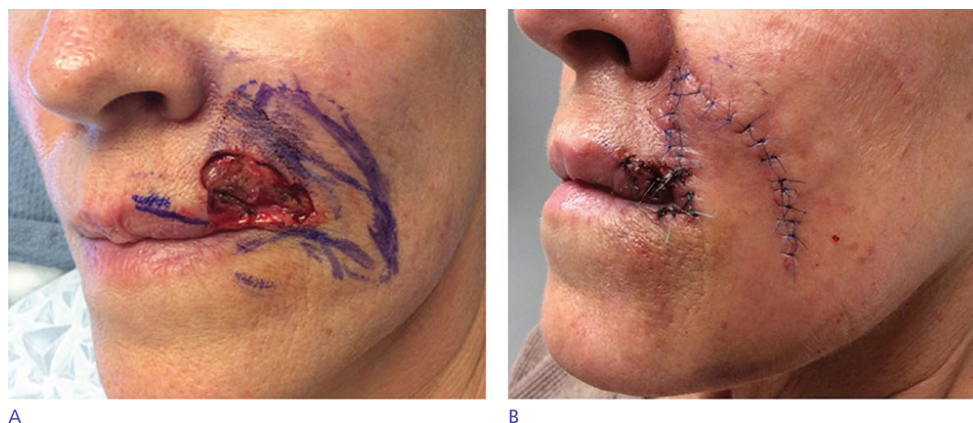


Figure 22-19. Left upper lip rotation flap involving the vermilion border. (A) Preoperative appearance. (B) Postoperative appearance.

A similar flap that recruits tissue from the medial cheek has been effective in closing large defects of the cutaneous upper lip. This technique involves creating a template of the entire upper cutaneous lip subunit, to include the apical triangle, from the unaffected side and transferring it to the medial cheek of the affected side. The flap is then incised, maintaining an inferiorly base pedicle and undermined superficial to the orbicularis oris muscle. Once rotated into place, the flap recreates the entire upper cutaneous lip lateral to the philtral column. The lateral border of the flap recreates the nasolabial fold. Finally, the secondary defect on the cheek is repaired primarily.²⁸

FOREHEAD AND TEMPLE

The cosmetic boundaries of the frontal and temporal hairlines are well suited for hiding the long arcuate incisions created by rotation flaps. Traditional single-arm rotation flaps and double rotation flaps both have utility in these anatomic locations (Figs. 22-20 and 22-21). Asymmetric double-opposing flaps, one arm of which rotates while the other arm advances, have been shown to be highly effective for reconstructing defects on the temple, mid-forehead, and along the hairline. A recent series demonstrated good cosmesis without any alteration in eyebrow position in defects ranging from 3 to 30 cm.²⁹ Bilaterally symmetric double rotation flaps can also be effective for repair of defects along the hairline. Similar in design to the flap previously described in this chapter for defects on the chin, the long curved incision

lines frame the forehead creating two similarly shaped rotation flaps on either side of the defect. These flaps are rotated toward each other and the leading edges are sutured together along the midline after removing a small standing cone deformity inferiorly.

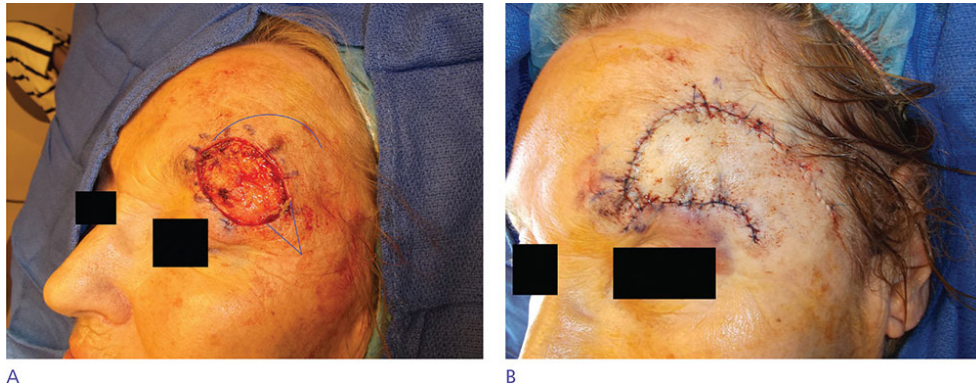


Figure 22-20. Large defect of the lateral forehead involving the lateral eyebrow. A rotation flap is designed to recruit tissue laxity from the temple—an ample reservoir.

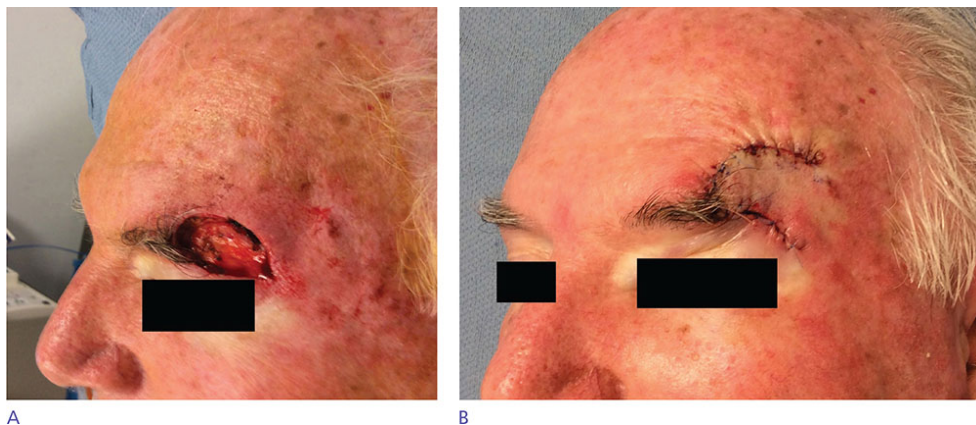


Figure 22-21. Another rotation flap repair of the lateral eyebrow with good cosmetic outcome.

EAR

Though typically not considered a standard reconstructive option on the ear, rotation flaps may be employed to repair few, appropriately selected defects (Fig. 22-22). Specifically, defects of the antitragus may be aptly located for recruiting tissue laxity from the adjacent lobule. A flap with a superomedially based pedicle and an arc of rotation along the curvature of the scaphoid fossa can be rotated to repair defects in this location.



Figure 22-22. Rotation flap repair of the antitragus of the ear. Tissue laxity was recruited from the lobe in this situation.

COMPLICATIONS AND MANAGEMENT

Rotation flaps are susceptible to many of the same pitfalls that affect other types of flaps. The potential for postoperative bleeding is ever present in dermatologic surgery. A thorough preoperative evaluation to include the patient's use of anticoagulants is critical in identifying those at risk for this complication. Careful attention to intraoperative hemostasis, especially beneath the flap, is of the utmost importance, as a newly inset flap forms a potential space for hematoma formation. Bulky pressure dressings are another key component of preventing bleeding in the postoperative period.

Should persistent bleeding continue beneath the flap during the postoperative period, a true hematoma may develop. Within the first 24 to 48 hours following surgery, hematomas should be evacuated to ensure the greatest chance for flap survival. If the hematoma is not yet organized, attempts can be made to remove the blood with a syringe and 18-gauge needle. However, it is likely that the sutures will need to be removed and the hematoma physically evacuated while also irrigating the wound. This additionally offers the opportunity to visualize and address the source of bleeding, a critical step if the hematoma seems to be increasing in size. Once the wound bed and base of the flap are clean and dry, the flap may be resutured in place. Outside of the first 2 days postoperatively, hematomas are more likely to be organized and less amenable to evacuation. Not only do hematomas create pressure that may compromise flap perfusion, they also significantly increase the risk of wound infections that may adversely affect

flap viability. Thus regardless of the time following surgery, the presence of a hematoma is an indication for prophylactic antibiotics, as hematomas serve as a nidus of infection.

Complications that are unique to rotation flaps derive from the design and tissue movement of these flaps. As stated previously, rotational shortening is inherent in the expected movement of rotation flaps. When unaccounted for, rotational shortening can produce excessive tension on the leading edge of the flap. This may result in dehiscence of the wound or flap ischemia and necrosis along this edge. Unnecessarily high tension due to rotational shortening may be combated by increasing the length of the leading edge of the rotation flap beyond the defect. Also, wide undermining of the flap and the surrounding tissues further minimizes this risk.

In most cases, the geometric design of rotation flaps helps to ensure robust perfusion. One instance in which this blood supply may be compromised is with the use of a backcut to relieve pivotal restraint. When performing a backcut, the dermatologic surgeon must take care not to overly narrow the pedicle. Maintaining a length-to-width ratio of no more than 3:1 mitigates this risk.

Finally, rotation flap may also be complicated by altering the position of free margins. The long arcuate incisions often created by these flaps result in long secondary defects. It is important to be cognizant of the course of these secondary defects, especially when in close proximity to free margins. To varying degrees, there will always be secondary movement of the surrounding tissue to close the secondary defect. While it is true that increasing the length of the arc of rotation will decrease tension across the secondary defect, this must be weighed against extending the secondary defect to an anatomic location where a given amount of secondary tissue movement is unacceptable.

CONCLUSIONS

The rotation flap is a workhorse in the reconstructive toolbox of the dermatologic surgeon, and can be employed in a wide range of anatomic locations. As with many other random pattern flaps, the rotation flap has the advantage of good local tissue match with regard to texture, thickness and presence of adnexa. It is a reliably robust flap owing to its broad pedicle

inherent in its basic design. Generally, this flap is conceptually and technically simple to execute when proper planning and design considerations are accounted for. The modern dermatologic surgeon must be prepared to approach every surgical defect as unique. There is not a single “cookie-cutter” repair that is appropriate for all wounds of a given location. Often, an innovative combination closure is required incorporating a blend of flaps, grafts, primary closure, or second intention healing.

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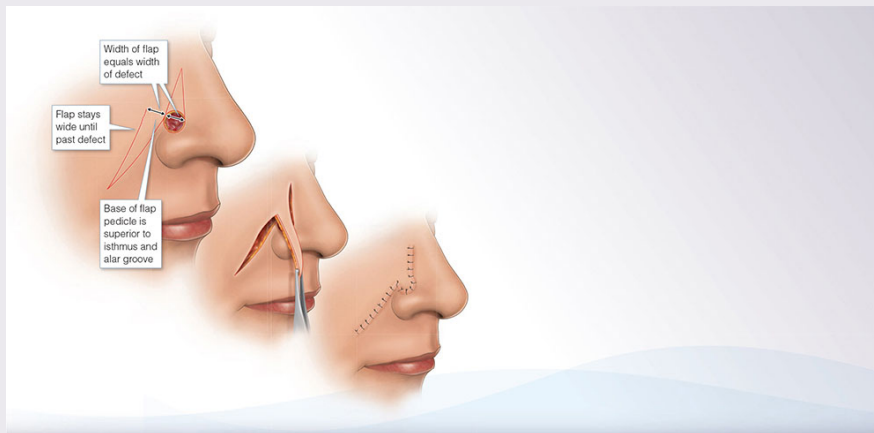
CHAPTER 23 Transposition Flaps

Thuzar M. Shin

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Joseph F. Sobanko

Christopher J. Miller



SUMMARY

- With transposition flaps, the position of the main tension vector is changed from the primary defect to a more ample adjacent tissue reservoir, and the elevated flap is transposed under little to no tension.

- The ability of transposition flaps to push tissue into the defect by redirecting tension vectors perpendicular to the primary closure direction, coupled with their ability to close a defect using a smaller total surface area than sliding flaps (and the possible added benefit of a broken-up repair line), make these flaps particularly useful for larger facial defects.

Beginner Pearls



- The pinch test may be useful to assess both the primary wound and nearby tissue reservoirs.
- Visualizing a rhombic flap as a rotation flap with a large backcut helps illustrate the consequence of pivotal restraint on flap movement.

Expert Pearls



- The takeoff point can influence flap vascularity and length, and is usually at the midpoint of the defect.
- The nasolabial single-lobed transposition flap is useful for reconstructing defects of the ala, though this flap can appear thick and pincushion without a precise undermining plane and tacking sutures to recreate the alar groove.

Don't Forget!



- The curved lines that result from most transposition flaps require meticulous suturing, as they rarely fall along cosmetic subunit junctions or relaxed skin tension lines. This attention to detail is particularly critical for successful execution of flaps on sebaceous skin, such as the distal nose.
- Taking off from the long axis of an asymmetric defect requires a greater arc of rotation and flap length, which both threaten the flap's blood supply. Distal takeoff points narrow the pedicle and compromise the blood supply.

Pitfalls and Cautions



- Pincushioning, or trapdoor deformity, may occur with transposition flaps, especially on the nose. Several etiologies have been suggested, such as excessive flap thickness, inadequate undermining, and circumferential wound contraction. Strategies to minimize pincushioning include appropriately sizing the flap, careful suturing of all anatomic layers, and closing any dead space under the flap. If intralesional corticosteroids do not resolve pincushioning, surgical thinning may be necessary.

Patient Education Points



- When recruiting tissue from distant sites, transposition flaps may not match the contour, texture, and hair density of the defect. Surgeons may counsel patients when additional procedures, such as staged surgery or hair removal, are anticipated.
- Transposition flaps that span multiple facial subunits may ablate cosmetic subunit junction lines. Patients may be prepared for the possibility of staged reconstruction to restore a concave subunit junction, such as the alar groove or melolabial fold.

Billing Pearls



- Flap repair codes (140XX series) include the excision component, so it is not appropriate to bill both an excision and a flap repair code simultaneously.
- Mohs codes may be submitted along with flap repair codes, though they may be subject to the multiple-procedure reduction rule.
- When coding a flap, medical necessity is the ultimate arbiter of appropriateness.

CHAPTER 23 Transposition Flaps

INTRODUCTION

Transposition flaps are often useful when tension at the primary defect precludes side-to-side closure or the use of sliding flaps, such as advancement or rotation flaps. To transpose means to switch positions, which aptly describes the flap's essence, as the position of the main tension vector is changed from the primary defect to a more ample adjacent tissue reservoir, and the elevated flap is transposed into the primary defect under little to no tension. Common transposition flaps include the rhombic (single-lobed), bilobed, and trilobed flaps, though the latter two flaps, in particular, involve a significant rotational component.

The ability of transposition flaps to push tissue into the defect by redirecting tension vectors perpendicular to the primary closure direction, coupled with their ability to close a defect using a smaller total surface area than sliding flaps (and the possible added benefit of a broken-up repair line), make these flaps particularly useful for larger facial defects.

PRINCIPLES OF TRANSPOSITION FLAP DESIGN AND EXECUTION

Using the pinch test to assess the primary wound for flap selection

Pinching, or squeezing together the primary wound edges, is a simple strategy to guide flap selection. If pinching easily approximates the wound edges, then side-to-side closure or a sliding advancement or rotation flap will usually be possible (Fig. 23-1). If pinching cannot approximate the wound edges

because of excessive tension or anatomic distortion from pulling or compressing free margins (e.g., eyelids, distal nose, lips), then a transposition flap may be useful to transfer tension to and recruit tissue from a more generous adjacent reservoir.



Figure 23-1. Pinching the primary wound edges guides flap selection. A linear closure or sliding flap is usually possible if the wound edges are easily approximated. If pinching the wound edges causes excessive tension or free-margin distortion, a transposition flap may be useful to transfer tension to and recruit tissue from an adjacent reservoir.

Using the pinch test to identify a donor tissue reservoir

After determining that direct closure of the primary wound is not possible, the pinch test can identify a suitable donor site for a transposition flap (Fig. 23-2). If the skin immediately adjacent to the wound pinches easily and without anatomic distortion, a single-lobed rhombic flap may be possible. If the skin adjacent to the primary wound is too tight, then the pinch test may identify a sufficiently lax tissue reservoir more remote from the primary wound. A bilobed or trilobed flap may be necessary to reach a distant reservoir.



A



B



C



D

Figure 23-2. A suitable tissue reservoir for a transposition flap is identified using the pinch test. For this defect on the preauricular cheek, tissue reservoirs located posteriorly (A) and superiorly (B) lack sufficient volume, laxity, and vascularity. The anterior tissue reservoir (C), while ample, may lead to

anatomic distortion. An inferior donor site (D) pinches easily without anatomic distortion and would be ideal. In order to reach this donor site, one or more lobes may be needed.

Assessing a wound on the distal nose illustrates the pinch test application. If pinching the tight, adherent distal nasal skin fails to approximate the wound edges, alters the position of the free margin, or compresses the nasal cartilages, then a transposition flap is considered. The pinch test is then applied to surrounding skin to identify a donor site. The skin of the nasal sidewall and proximal dorsum pinch easily without distorting the shape of the nose (Fig. 23-3A). If the primary wound is directly adjacent to one of these reservoirs, a single-lobed rhombic flap may be possible (Fig. 23-3B). Adding lobes for a bilobed or trilobed flap may be necessary to bridge the distance between the primary wound and the tissue reservoir (Fig. 23-3C).

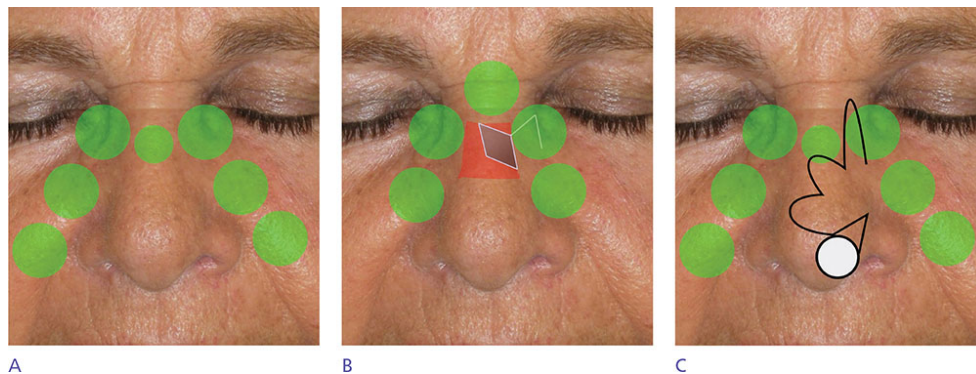


Figure 23-3. (A) Tissue reservoirs on or near the nose. (B) A single-lobed rhombic flap may be used when the tissue reservoir is immediately adjacent to the primary defect. (C) Two or three lobes may be needed for more distal defects in order to bridge the distance between the primary defect and an appropriate donor site.

Tension vectors

Transposition flaps reorient and displace tension vectors to adjacent tissue reservoirs, thereby preserving the position of free margins and restoring contour at the primary defect. In general, tension is transferred from the primary defect to the terminal donor site or lobe (i.e., the secondary lobe of a bilobed flap and the tertiary lobe of a trilobed flap; Fig. 23-4). Closing the terminal donor site should allow rotation of the flap into the primary defect with minimal tension (Fig. 23-5). If tension at the primary defect is still excessive, strategically placed tacking sutures can anchor flaps to immobile

structures and minimize tension across the dermal sutures (Fig. 23-6). On the central face, tacking the undersurface of the flap to the origin of the zygomaticus major muscle, the inferior orbital rim, or the medial canthal tendon can prevent lower eyelid ectropion, and tacking sutures to the pyriform aperture can mitigate the risk of alar margin distortion. These tacking sutures also recreate contour when transposition flaps drape over concavities, such as the alar groove or nasal facial sulcus.

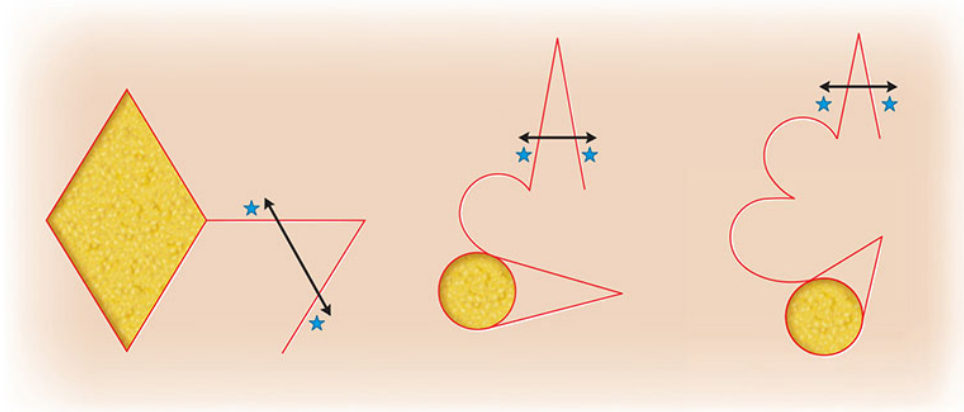


Figure 23-4. Transposition flaps displace tension from the primary defect to the final donor site (*stars* denote key stitch and *arrows* demonstrate direction of tension vector).

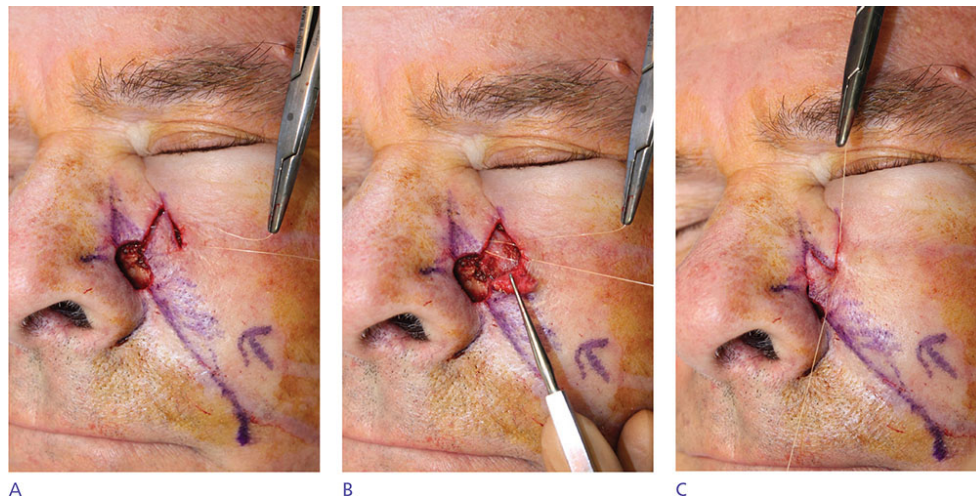


Figure 23-5. Closing the terminal donor site allows transposition of the flap into the primary defect with minimal tension. (A) Rhombic flap designed and incised. (B) The first key stitch closes the donor site. (C) After closure of the donor site, the flap drapes over the primary defect.

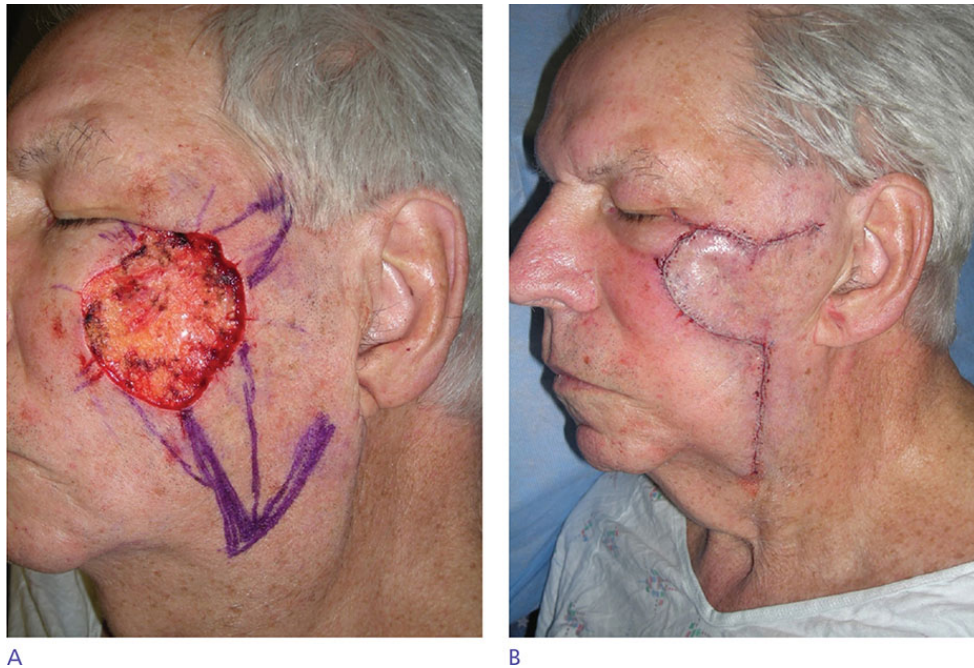


Figure 23-6. Secondary motion from suture placement near the inferior lateral orbital rim, where a secondary key stitch would be placed, may risk ectropion. This is mitigated by use of tacking sutures from the undersurface of the flap to the origin of the zygomaticus major, thereby suspending the flap in place and minimizing secondary motion near the vulnerable eyelid.

Pivotal restraint and flap shortening with increased angle of rotation

Visualizing a rhombic flap as a rotation flap with a large backcut helps illustrate the consequence of pivotal restraint on flap movement (Fig. 23-7). The fixed base at the pedicle tethers the flap and serves as a pivot point as the flap is rotated toward the primary defect. The pivot points for a rhombic flap are shown in Figure 23-8. As the arc of rotation increases, pivotal restraint increasingly restricts and shortens the flap length.¹ If the shortened flap does not have enough surface area to cover the defect, the consequent secondary motion of the recipient tissue will increase tension at the primary defect and may compromise the blood supply of the distal flap (Fig. 23-8). Preoperative flap design must account for pivotal restraint to avoid excessive tension, especially if secondary motion would displace a free margin.

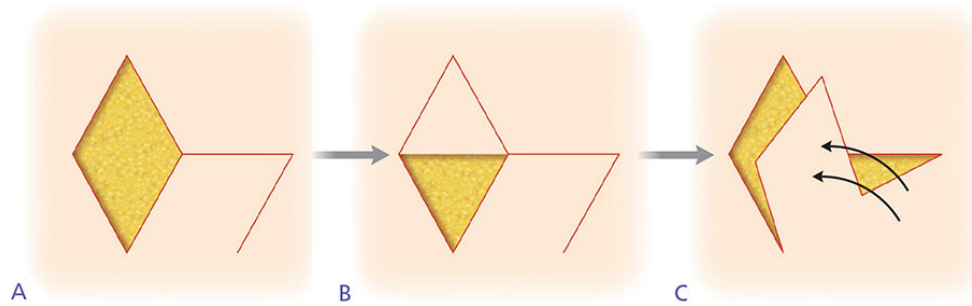


Figure 23-7. A rhombic flap depicted as a rotation flap with a large back cut. As with a rotation flap, a rhombic flap is subject to pivotal restraint both at the base of the defect and at the terminus of the back cut.

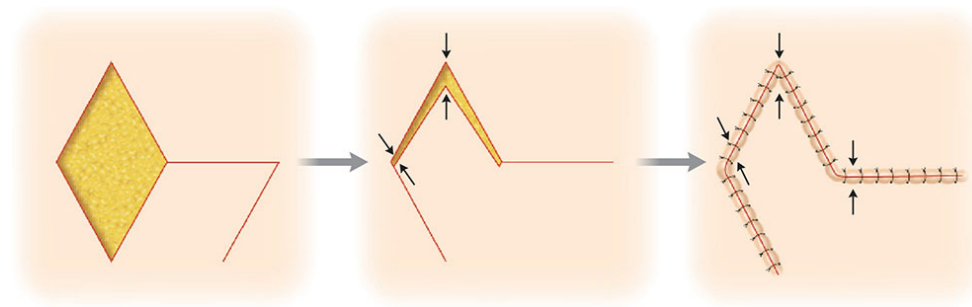


Figure 23-8. If the flap design does not take into account the consequences of pivotal restraint and the recipient site is unable to provide secondary motion, excess tension may compromise blood supply to the distal edges of the flap.

Placement and excision of standing cones

When the flap is transposed to the primary defect, a standing cone, or dog ear, forms at the base of the pedicle. As the arc of flap rotation increases, the standing cone encroaches further into the vascular pedicle of the flap (Fig. 23-9). The standing cone is typically excised to prevent contour irregularities, though if immediate excision would narrow the pedicle and threaten the flap's blood supply, removal can be delayed.

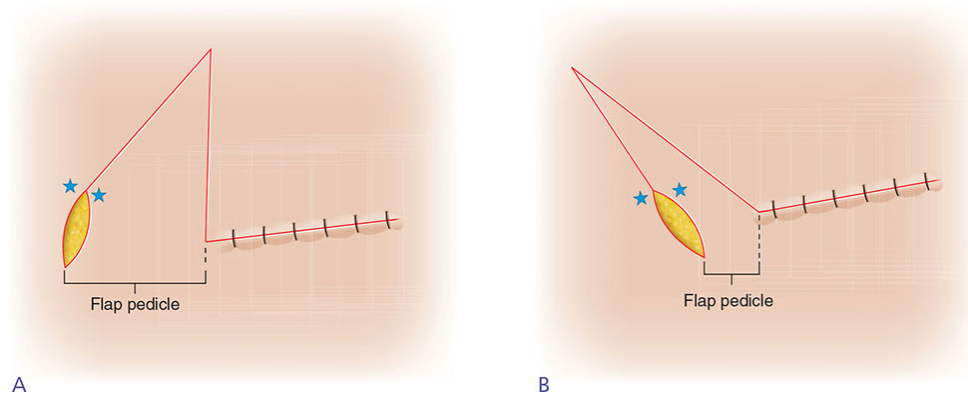


Figure 23-9. An increased arc of rotation when transposing a flap into the primary defect results in further encroachment of the standing cone into the flap pedicle, which can compromise blood supply. The standing cone is directed away from the vascular pedicle when possible. Delayed removal can be considered if immediate removal would threaten the flap's viability.

Influences on flap vascularity

Flap vascularity is primarily influenced by three factors:

- (1) the depth of flap elevation;
- (2) the width of the flap pedicle;
- (3) the distance from flap tip to base of flap.

Depth of flap elevation

The depth of flap elevation impacts the size and perfusion pressure of the vessels within the pedicle. Deeper elevation planes incorporate vessels with larger diameters and greater perfusion pressures. The plane of flap elevation differs by anatomic location, and appropriate selection of undermining planes balances maximizing the blood supply with protection of critical anatomic structures (especially branches of the facial motor nerve). Most transposition flaps are elevated at the junction of the subdermal fat and fascia (Fig. 23-10). Routine exceptions include flaps on the midline nose and forehead, which are usually elevated deep to the muscles of facial expression, and those on the scalp, which are elevated deep to the galea aponeurotica (Fig. 23-11).

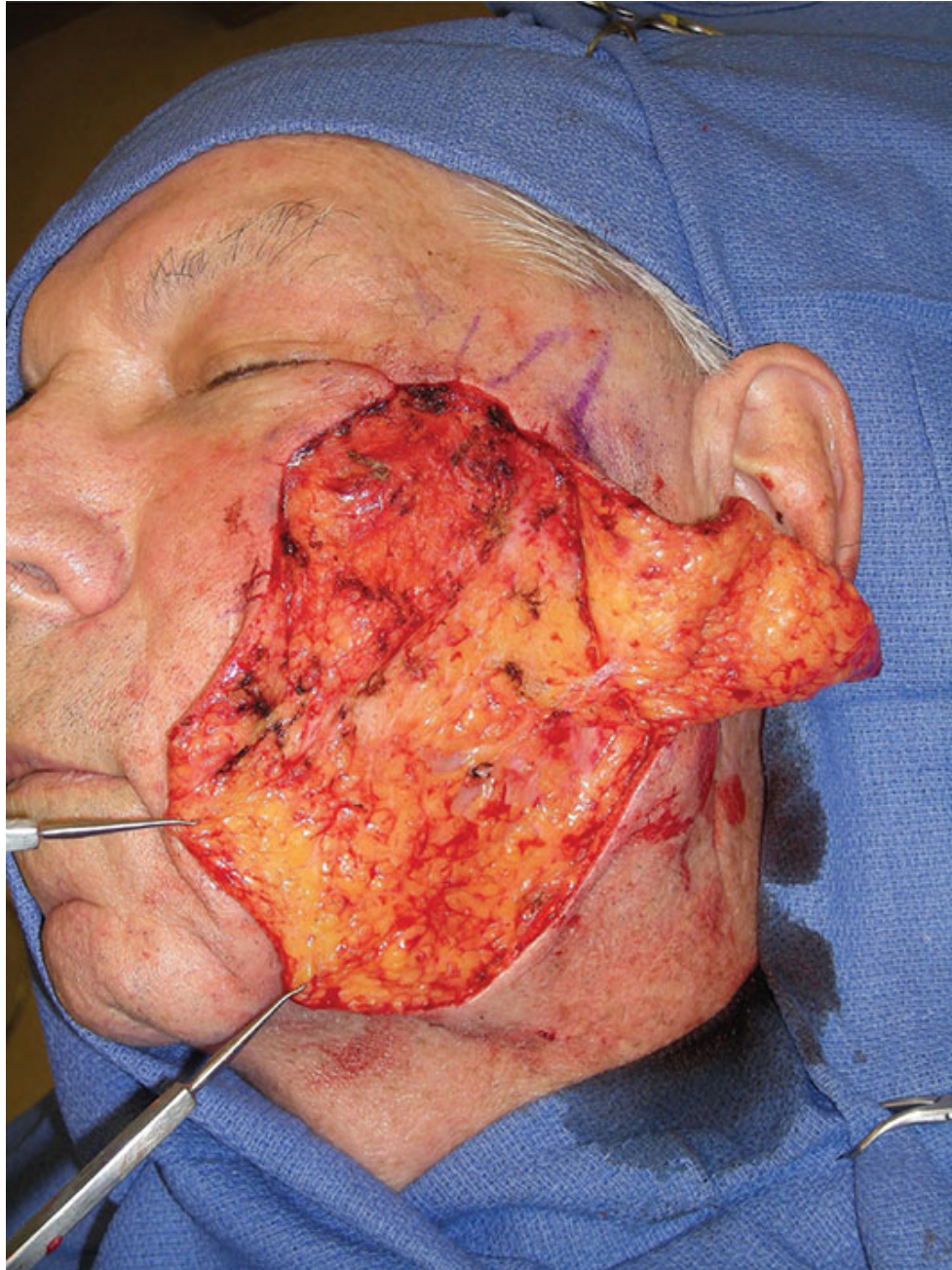


Figure 23-10. Transposition flap elevated underneath the subdermal fat, which consists of smaller, tightly packed lobules. Note that the plane of undermining is above the larger lobules of the buccal fat pad.



Figure 23-11. Transposition flaps on the nose are elevated deep to the muscular layer, above the perichondrium or periosteum.

The width of the flap pedicle

A narrow vascular pedicle compromises the blood supply to the flap. Factors influencing the pedicle width include the flap takeoff point and angle from the defect, the location of the standing cone at the pedicle base, and the number of lobes of the flap (e.g., bilobed versus trilobed). Distal takeoff

points result in a narrower pedicle than a proximal takeoff point (Fig. 23-12). The takeoff angle is the angle created between the first limb of the rhombic flap and the primary defect (Fig. 23-13A). As the takeoff angle becomes more acute, the width of the flap pedicle increases (Fig. 23-13B). However, more acute takeoff angles usually require greater secondary motion around the primary defect for wound closure. As noted above, as the arc of flap rotation increases, the standing cone encroaches further into the vascular pedicle of the flap. Finally, as the number of lobes increases, the width of the flap pedicle is enlarged, increasing flap vascularity (Fig. 23-14).

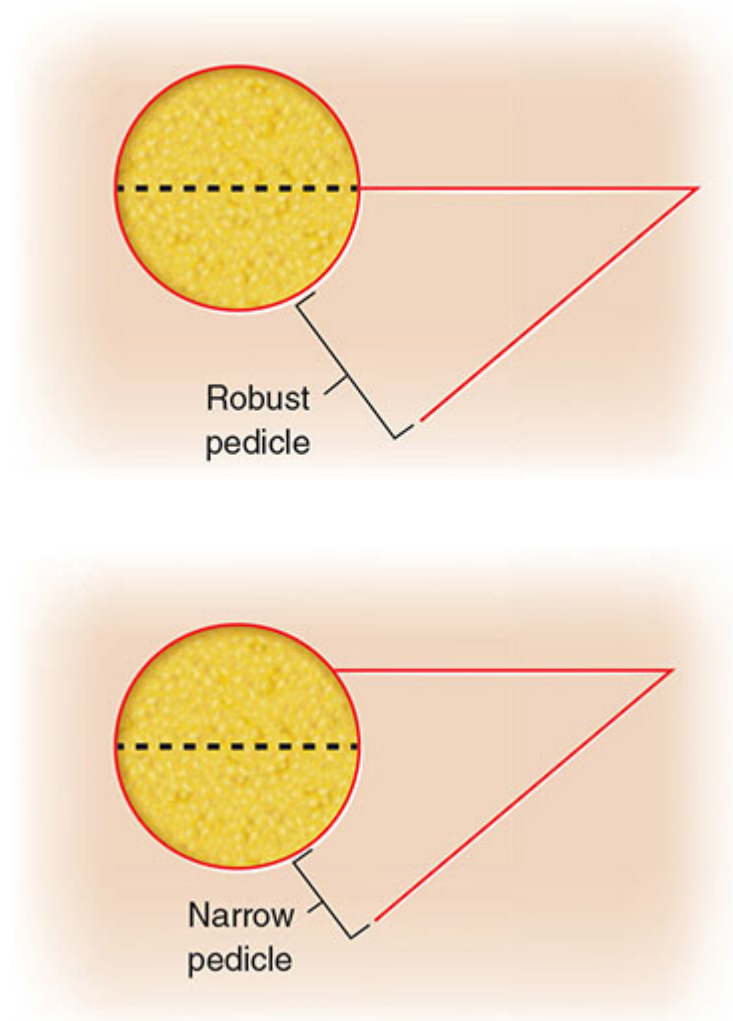


Figure 23-12. Compared to flaps with a takeoff at the midpoint of the defect (**top**), flaps with distal takeoff points result in a narrower vascular pedicle, which may compromise blood supply (**bottom**).

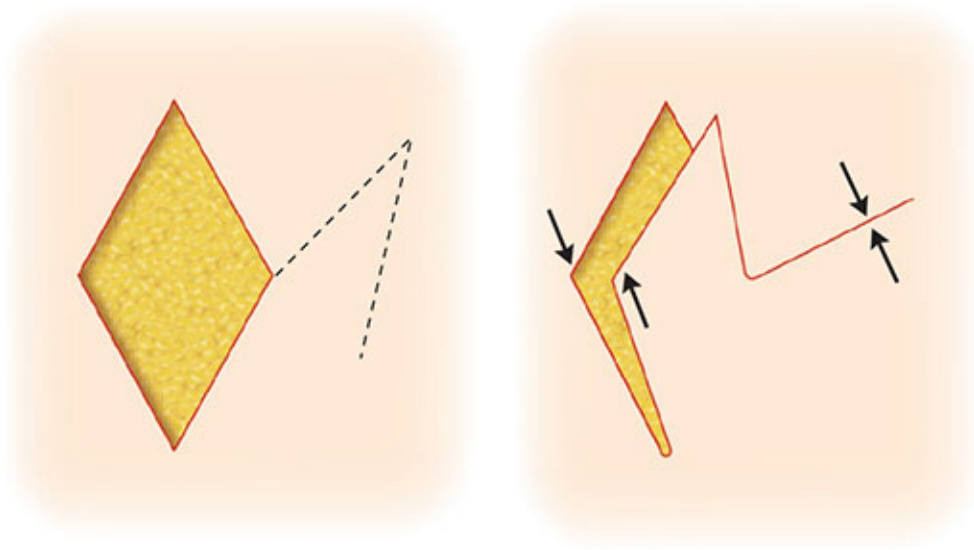


Figure 23-13. Closure of the donor site of a flap with an acute takeoff angle widens the defect, increasing the sharing of tension at the recipient site. Conversely, flaps that take off at a right angle to the defect require less secondary motion.



Figure 23-14. Bilobed flap design for a defect on the distal nose. The standing cone has a slight vertical orientation to avoid alar elevation. Note the narrow and tenuous vascular pedicle (*bracket*). Closure of the tertiary defect (*green arrows*) would distort the alar free margins. Converting from bilobed to trilobed flap (**B**) results in a wider, more robust vascular pedicle (*bracket*) and creates a terminal donor site that is vertically oriented to minimize alar distortion located at more favorable position within a generous tissue reservoir that facilitates side-to-side closure (*green arrows*).

The length of the flap relative to the pedicle width

The transposition flap's distal tip is most vulnerable to ischemia, and all long flaps with narrow pedicles are vulnerable to ischemic compromise.

Transposition flaps are often purposefully drawn with a long distal tip and apical angle of 30 degrees or less to ease closure and minimize standing cone formation at the terminal donor site (banner flap design). Consequently, the flap is frequently longer than necessary to cover the defect. Either the defect can be extended and angulated to accommodate the triangular tip, or the distal flap can be trimmed to match the rounded defect. Trimming the angulated distal flap to fit the rounded defect reduces the risk of ischemia and is generally preferable.

Tension on the flap

High tension on the flap increases the risk for ischemia. Common causes of tension include a flap with less surface area than the defect and transposition of the flap to a recipient bed with tight immobile skin. Transposition flaps on the scalp are particularly vulnerable to excessive tension.

Altering the defect or the flap to optimize flap design and execution

In order to maintain the appropriate contour of the recipient site, the primary defect is often deepened to match the flap thickness. For example, a shallow defect on the nasal tip may be deepened to perichondrium to match the thickness of a bilobed flap, which is elevated in the perichondrial plane.

Additionally, the defect may be altered or enlarged to place scar lines along cosmetic subunit junctions. For instance, on the nasal ala, the defect may be extended to the alar rim to camouflage the horizontal scar line from a nasolabial transposition flap. Similarly, a defect on the lip may be extended to the vermilion-cutaneous junction (Fig. 23-15).



Figure 23-15. A defect on the upper lip is extended to the vermilion–cutaneous junction in order to camouflage the incision within the cosmetic subunit junction. Preoperative view and design (A), appearance immediately after closure (B) and appearance prior to revision to recreate the melolabial fold (C).

CONSIDERATIONS FOR SPECIFIC TRANSPOSITION FLAPS

Single-lobed (rhombic, nasolabial, or banner) transposition flaps

The donor site of single-lobed transposition flaps is immediately adjacent to the defect. This proximity magnifies the impact of donor site selection and flap design on the ease of wound closure, flap vascularity, and the degree of secondary motion required to close the defect.

Surface area of the flap versus the primary defect

The appropriate donor site for a single-lobed flap should have adequate tissue laxity to close the secondary defect after elevating a flap with sufficient surface area to cover the primary defect. Pinching the skin adjacent to the wound gauges tissue laxity. If the surface area of the flap and primary defect are similar, secondary motion at the primary defect will be minimized. If tension at the donor site requires an undersized flap, secondary motion will

be necessary to close the difference between the flap and the primary defect, potentially displacing adjacent free margins (Fig. 23-16).

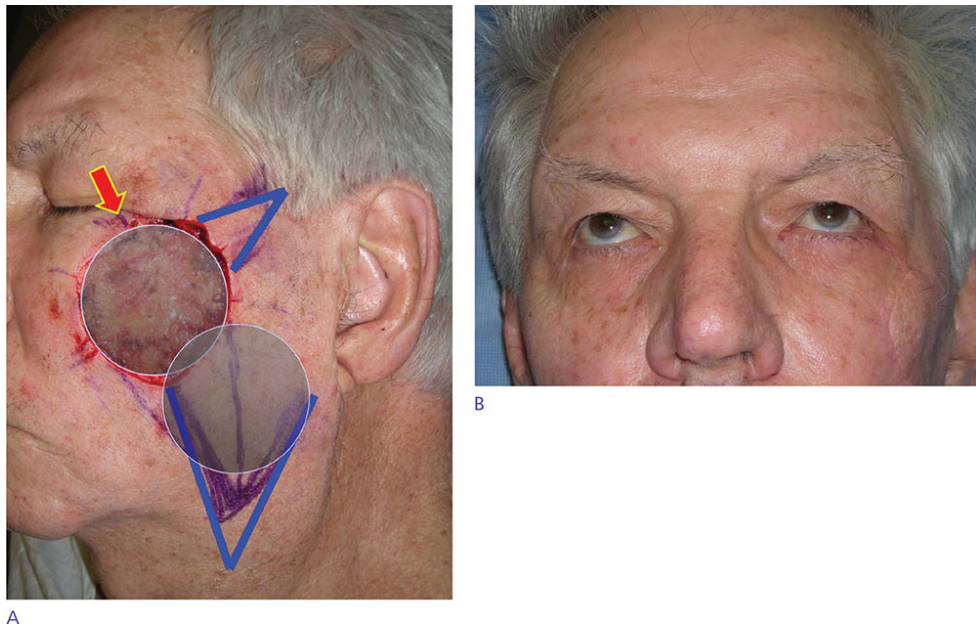


Figure 23-16. Minimal secondary motion at the recipient site is required when the flap area is equal to the defect area. An undersized flap increases the degree of secondary motion at the primary defect. In critical anatomic areas, secondary motion at the recipient site increases the risk of free-margin distortion. A rhombic flap with a surface area equal to that of the defect is designed (A). Two-month follow-up shows excellent eyelid position (B).

The impact of takeoff point and angle on blood supply and tissue biomechanics

After a suitable tissue reservoir is identified, one must determine both the takeoff point and angle. The takeoff point can influence flap vascularity and length. The takeoff point is usually at the midpoint of the defect (Fig. 23-17A). For ovoid or asymmetric defects, the takeoff point most often originates from the short axis. Taking off from the long axis of an asymmetric defect requires a greater arc of rotation and flap length, which both threaten the flap's blood supply. Distal takeoff points narrow the pedicle and compromise the blood supply (Fig. 23-17B). Occasionally, positioning the takeoff point closer to the base of the defect may be advantageous, as this increases the width of the vascular pedicle and may move the takeoff point (and the first key suture that bears maximal tension) away from critical

anatomic structures. The trade-off is that a longer, more vulnerable flap is necessary to reach the defect (Fig. 23-17C).

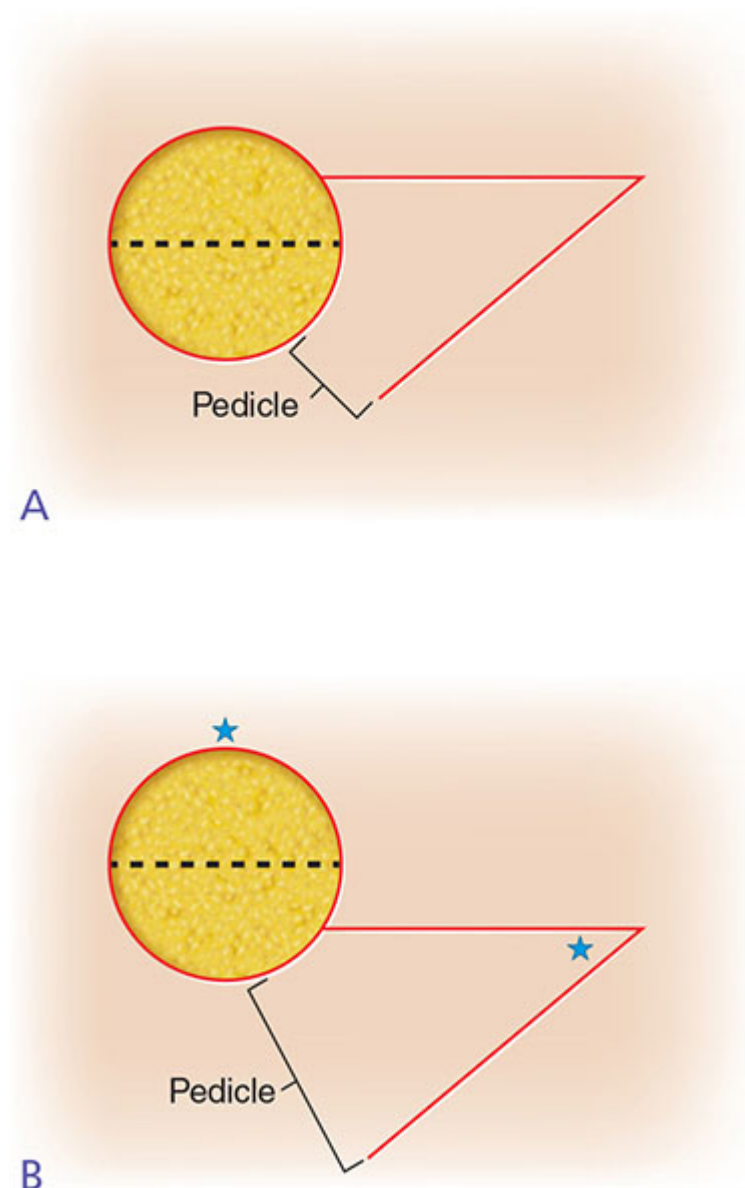
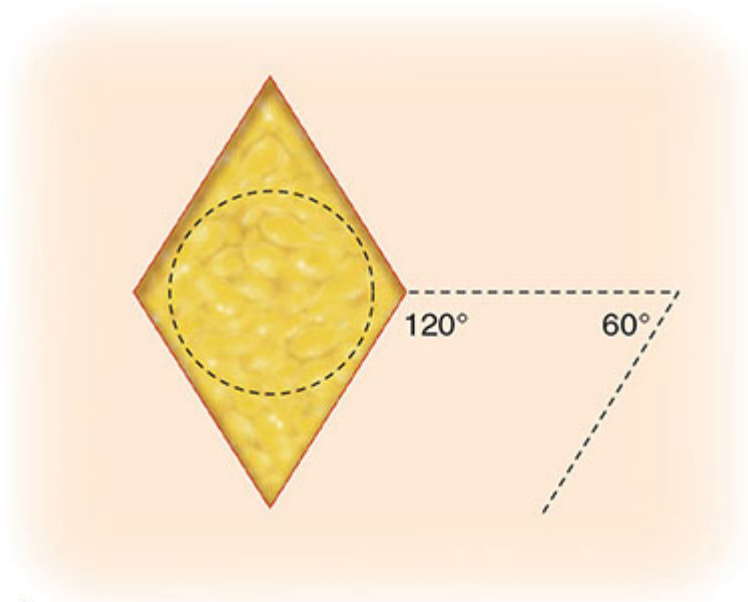


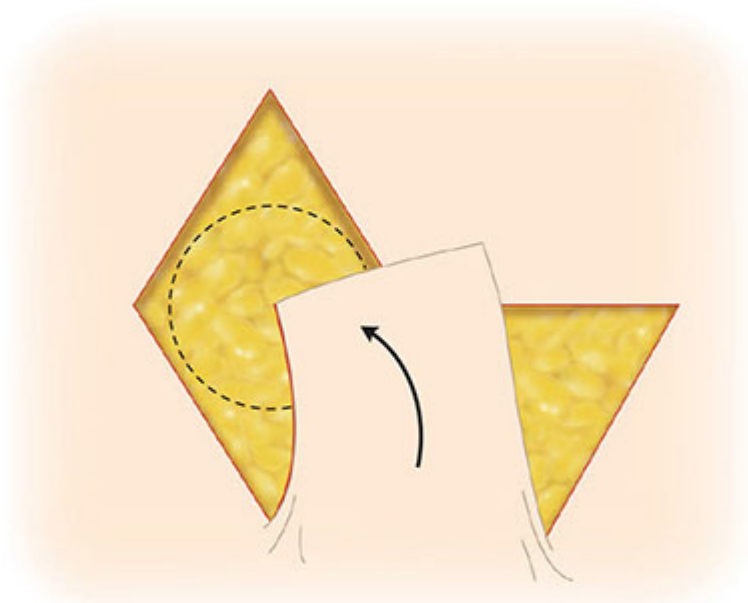
Figure 23-17. The flap takeoff point and angle of a rhombic flap impacts blood supply and tissue biomechanics. The takeoff point is usually at the midpoint of the defect, originating from the short axis for an asymmetric defect. (A) Distal takeoff point creates a narrow pedicle. (B) Proximal takeoff point results in a longer flap to cover the defect that may be vulnerable to ischemia.

The takeoff angle between the first limb of the rhombic flap and the primary defect also affects blood supply and flap biomechanics. To illustrate this principle, consider a traditional rhombic flap compared to the

Dufourmental modification. The traditional takeoff angle for the classic rhombic flap is perpendicular to the defect, resulting in a flap that moves 90 degrees into place. Due to the nearly perpendicular tension vectors of the first and second key stitches, there is minimal secondary motion at the primary defect (Fig. 23-18). Avoiding secondary motion is a priority for primary defect near free margins or with immobile surrounding skin. As the takeoff angle becomes more acute, the width of the flap pedicle increases. However, more acute takeoff angles usually require greater secondary motion around the primary defect, because the tension vectors to close the primary and secondary defects compete. The Dufourmental modification takes off at a more acute angle and decreases the flap's arc of rotation of the flap.² Closing the donor site of a flap with an acute takeoff angle widens the primary defect and requires secondary motion for closure around the relatively undersized flap (Fig. 23-19).



A



B

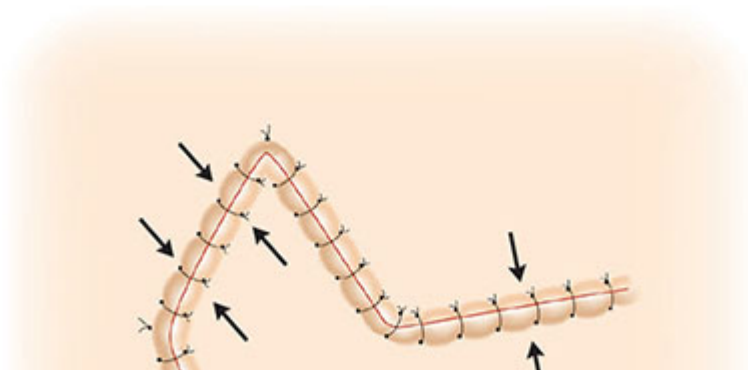




Figure 23-18. The takeoff angle between the first limb of the rhombic flap and primary defect is usually 90 degrees. There is no sharing of tension since the primary key stitch and secondary key stitch are nearly perpendicular. Acute takeoff angles result in competing tension vectors caused by closure of the primary and secondary defects. As a result, greater secondary motion is required at the primary defect.



Figure 23-19. Modified takeoff angle for a rhombic flap used to repair a defect on the proximal nose. (A) Flap design with an acute takeoff angle. (B) Immediate postoperative appearance. Note the secondary motion at the primary defect. (C) Six-month follow-up.

Banner flaps rely on a takeoff angle that is nearly tangential to the defect (close to 180 degrees); coupled with the removal of a standing cone at the opposite angle and the elevation of a long narrow flap pedicle (the banner), such flaps permit transposition of significant portions of tissue over large arcs.

Specific examples of single-lobed transposition flaps

Nasolabial transposition flap. The nasolabial single-lobed transposition flap is useful to reconstruct defects of the alar groove and ala, and is one of the most frequently performed banner flaps.³ The flap recruits tissue from the

generous reservoir at the nasolabial fold. Since the alar groove and ala have scant fat, and since the skin adheres firmly to the dermal insertions of the underlying muscles, this flap can appear too thick and pincushion without a precise undermining plane and tacking sutures to recreate the alar groove.

The key design characteristics of the nasolabial transposition flap are shown in (Fig. 23-20). The medial arm of the flap takes from the lateral aspect of the nasal defect and extends inferiorly along the nasolabial fold. The lateral arm of the defect extends along the cheek in a parallel line that gently tapers to join the inferior nasolabial fold with 30 degrees or less. The horizontal widths of the proximal flap and defect should be identical. The superior aspect of the cheek limb of the flap should remain a couple of millimeters inferior to the origination point of the medial limb. This slight discrepancy is important to orient the primary tension vector in a superomedial vector that recruits skin from the mobile buccal cheek.

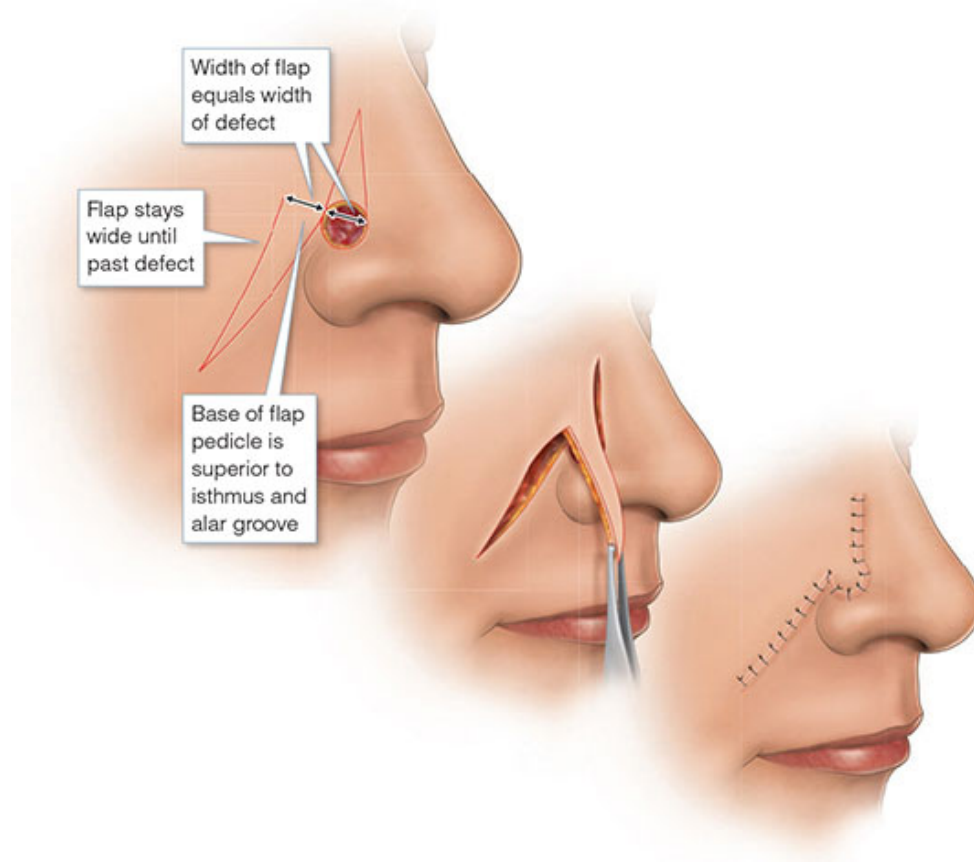


Figure 23-20. Design characteristics of the nasolabial transposition flap include equal widths of the flap and defect, maintaining the width of the flap until past the defect, and tapering the flap arms to an angle of 30 degrees or less.

The flap is elevated to include only the subdermal fat ([Fig. 23-21A](#)). If it includes the nasolabial fat pad, the flap will have too much volume. The nasolabial fold and cheek are undermined in the same tissue plane.

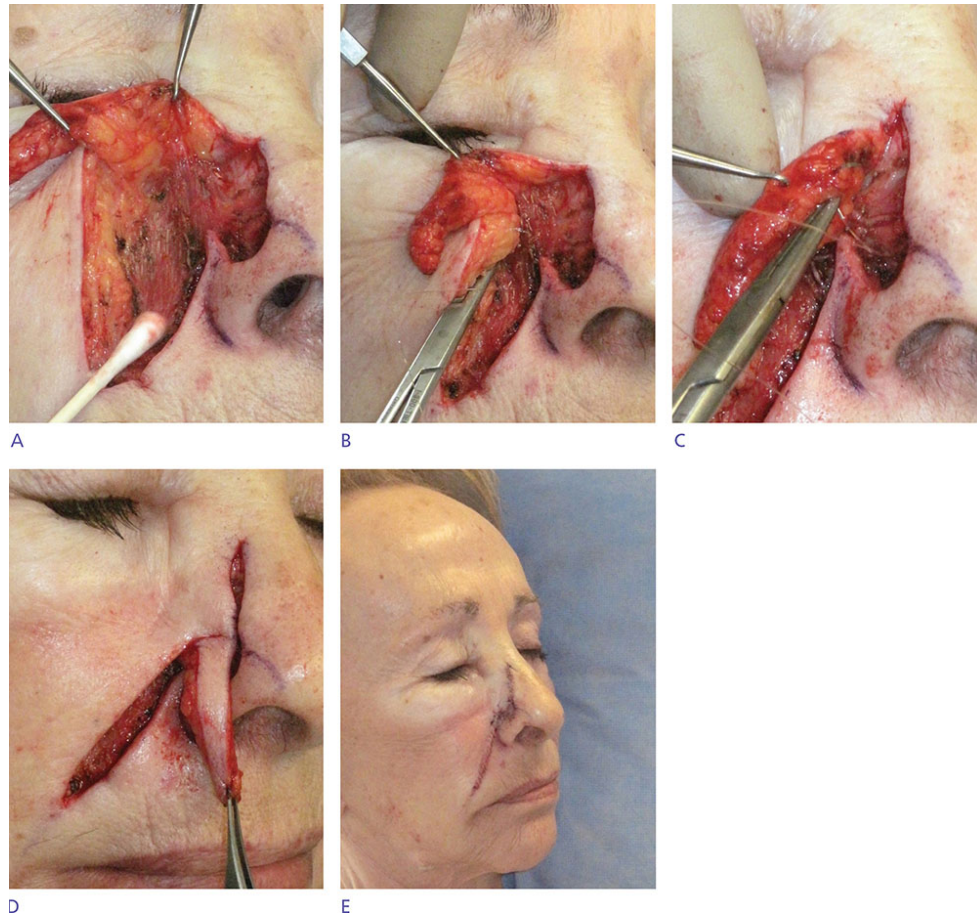


Figure 23-21. (A) Nasolabial transposition flap elevated under the subdermal fat and dissected off the lip elevators. Flaps that include the nasolabial fat pad will appear bulky. (B) Tacking the cheek to the pyriform aperture recreates the nasofacial sulcus and prevents distortion of the ala and tip. A slight dimple is desirable. (C,D) Tacking the base of the flap to the caudal margin of the transverse nasalis recreates the alar groove. A dimple is again desirable. (E) Desired contours should be evident immediately postoperatively.

The key suture closes the donor defect at the flap's origination point. If the wound is under high tension, tacking the cheek to the origin of the transverse nasalis along the pyriform aperture may be necessary to avoid lateral distraction of the nose ([Fig. 23-21B](#)). The distal portion of the flap is trimmed to match the size of the defect, and it is sutured to the primary defect. The alar groove has a deep concavity and the flap will pincushion if the dead space is not closed. Tacking the base of the flap to the caudal margin of the

transverse nasalis muscle is usually necessary to close dead space and restore contour of the concave alar groove (Fig. 23-21C). Transposition of the flap creates a standing cone along the nasal sidewall, which is removed while taking care to preserve the flap pedicle. Pincushion deformity of the transposed portion of the flap is the most common complication, which can be minimized by wide undermining of the recipient site in the perichondrial/periosteal plane, placement of tacking sutures on the flap to the base of defect, and judicious thinning of the flap resulting in a concave surface when the flap is inset. The desired contour should be present immediately postoperatively (Fig. 23-21D).

Double rhombic flaps. Two rhombic flaps may be used to cover defects that are too large for a single flap. Different variations of this strategy have been described. One variant has opposing rhombic flaps from the opposite sides of the primary defect (Fig. 23-22).^{4,5} Another variant has two mirror image flaps on each side of the primary defect.^{6,7} Each flap has a Dufourmentel modification with an acute takeoff angle, and they share a standing cone deformity when they are transposed.

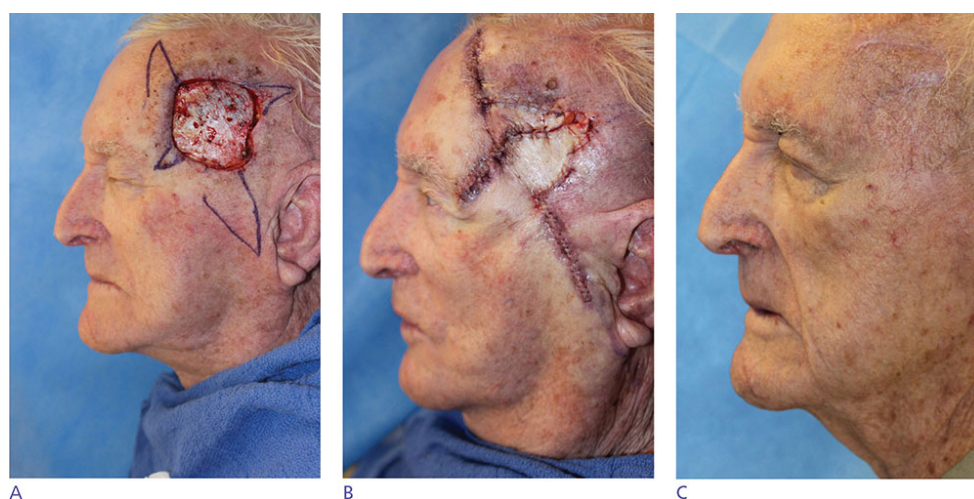


Figure 23-22 . Mohs defect on the temple repaired with opposing rhombic flaps. (A) Flap design. (B) Flaps sutured into place. (C) Three-month follow-up.

Multilobed (bilobed, trilobed, etc.) transposition flaps

When there is not enough issue immediately adjacent to the wound to allow closure with a single-lobed flap, additional lobes may be added to access a suitable tissue reservoir. A classic example is the use of bilobed and trilobed flaps to close distal nasal defects. The additional lobes access the more freely mobile tissue on the superior third of the nose, displacing tension away from the vulnerable free margin of the nose. Multilobed flaps are typically chosen when the surgeon needs to (1) recruit tissue from a more sizable reservoir than is available immediately adjacent to the defect, (2) reorient the tension vector of the key stitch or displace it to a more distant location, or (3) increase the width of the pedicle in order to minimize the risk of vascular compromise. For a full discussion of bilobed flaps, see [Chapter 24](#).

Specific examples of multilobed transposition flaps

Bilobed flap. If a rhombic flap is not possible because tension on the skin immediately adjacent to the primary defect is excessive or causes anatomic distortion, the bilobed flap can reach donor sites more remote from the defect. Compared to the rhombic flap, the geometry and execution of the bilobed flap are more complex. Excellent reviews have been written on this topic.^{8–11} The bilobed flap is most commonly utilized to repair wounds on the nose or near the eyelid, though it can be used in nearly any anatomic location ([Figs. 23-23 and 23-24](#)).¹²



Figure 23-23. Defect on the radial dorsal hand repaired with a bilobed flap. (A) Mohs defect. (B) Flap design. Note the more favorable location of the tertiary defect which facilitates closure. (C) Immediate postop appearance. (D) Long-term follow-up.



Figure 23-24. Defect on the right infraorbital cheek repaired with a laterally based bilobed flap. (A) Mohs defect and flap design. (B) Immediate postop appearance. (C) Long-term follow-up (14 months, treated with pulsed-dye laser).

Like the rhombic flap, the bilobed flap also rotates approximately 90 degrees. However, the bilobed flap distributes the rotation between the two lobes, each rotating 45 degrees. The second lobe incorporates a Z-plasty that helps to push the flap toward the primary defect (Fig. 23-25). If the primary defect is near a free margin, the tension vector to close the donor site for the secondary lobe (i.e., the tertiary defect) should generally be parallel to the free margin to preserve its position. To avoid secondary motion at a primary defect near a free margin, the primary lobe should also be sized to match the primary defect. The secondary lobe may have 85% to 90% of the surface area of the primary defect. The design details of a nasal tip defect repaired with a bilobed flap are shown in (Fig. 23-26).

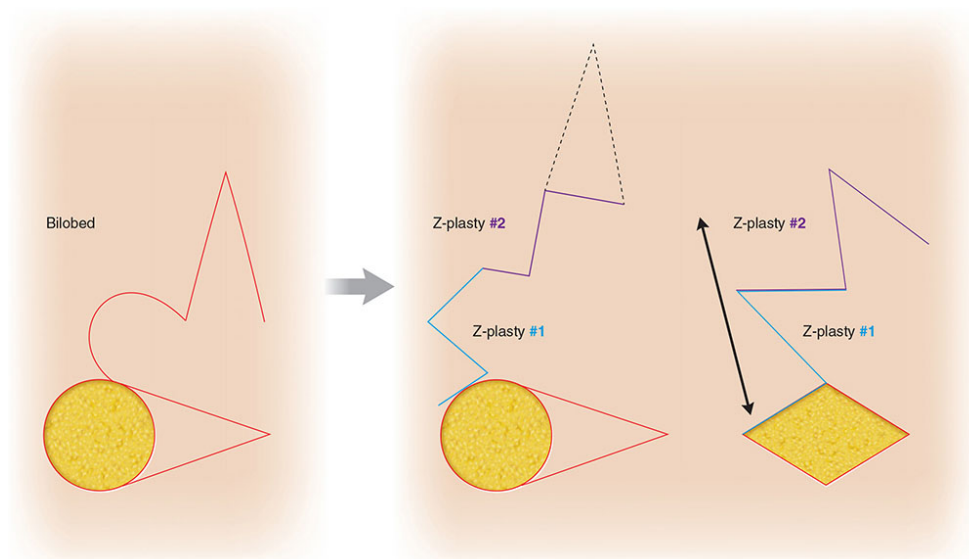


Figure 23-25. The bilobed flap represented as two consecutive Z-plasties that lengthen the flap.

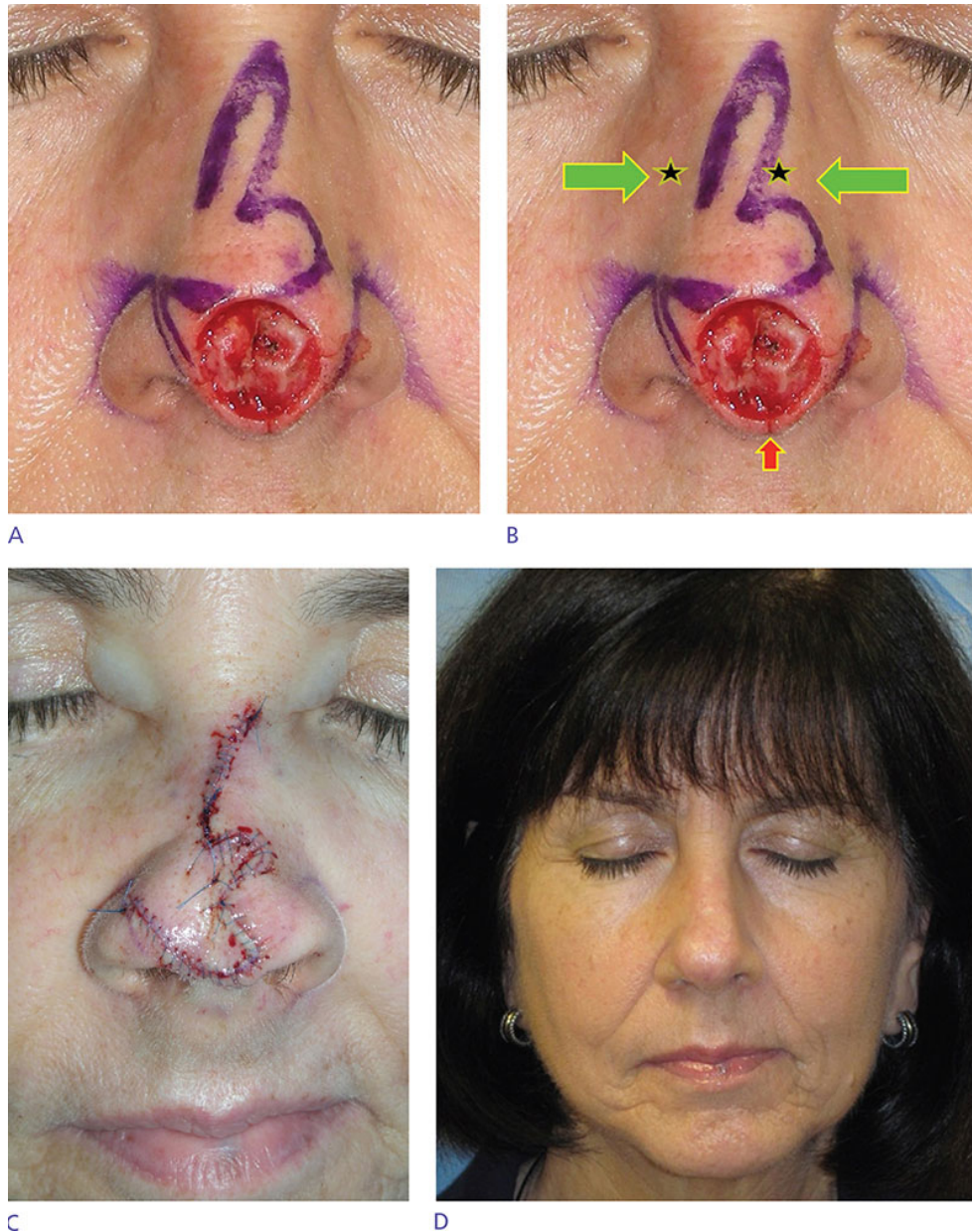
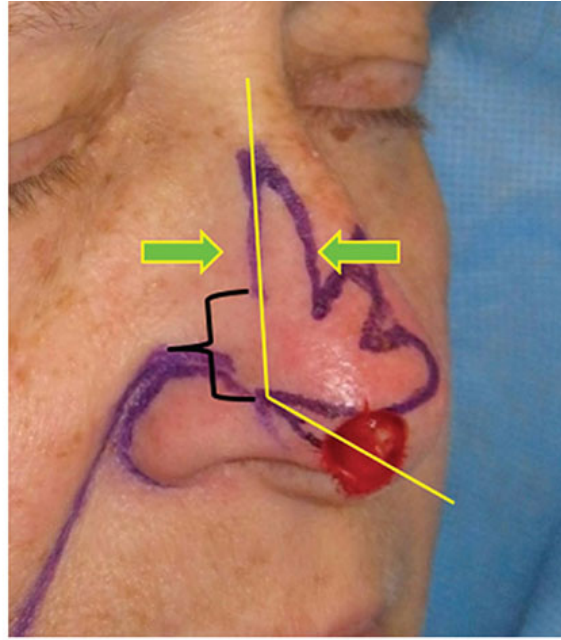


Figure 23-26 . Key design principles of a bilobed flap on the nose. (A) The diameter of the primary lobe is approximately equal to the diameter of the defect. The secondary lobe has a diameter 80% to 85% of the primary lobe and is not tapered too quickly. The standing cone is 30 degrees at the apex and oriented as vertically as possible without compromising the vascular pedicle. (B) Appropriately sized lobes minimize secondary motion at the nasal tip (*red arrow*). The final donor site is oriented such that the primary tension vector of its closure is parallel to the free margin (*green arrows*). (C) Immediate postoperative appearance. Note the absence of free-margin distortion. (D) Appearance at 8 months postoperatively after treatment with pulsed-dye laser.

The first key suture closes the tertiary defect and ideally pushes the flap toward the primary defect. The second key suture sets the primary lobe into

the defect. The exact position of this suture may vary or require adjustment to create tension vectors that avoid anatomic distortion, to align the standing cone, and to adjust the sizing of the primary lobe. The secondary lobe usually has excess length and must be trimmed to match the secondary defect.

Trilobed flap. The trilobed flap has tissue mechanics similar to the bilobed flap with a few distinct advantages (Fig. 23-27). First, its third lobe allows the flap to reach tissue reservoirs increasingly remote from the primary defect, and it is particularly useful to reconstruct distal nasal defects. Second, the third lobe extends the arc of rotation to 120 to 150 degrees and may provide a more favorable tension vector to close the quaternary defect. Third, the additional lobe adds the benefit of another Z-plasty, which decreases the tension to transpose the flap, an important advantage when even mild tension at the distal nose can distort the free margins. Finally, the third lobe increases the width of the flap pedicle. If the orientation of the standing cone would cut into the pedicle of a bilobed flap, the increased pedicle size of a trilobed flap can improve blood supply.¹³



A



B



C

Figure 23-27. The trilobed flap has several design advantages. (A) The flap rotates 120 to 150 degrees, places the final defect in a more favorable location such that the key tension suture preserves the position of alar margins, and allows for a wide, more robust vascular pedicle. The trilobed flap also gains an additional Z-plasty advantage. (B) Immediate postoperative appearance. Note the preservation of alar symmetry. (C) Six-month follow-up.

SPECIAL CIRCUMSTANCES FOR TRANSPOSITION FLAPS

1. *Delaying removal of the standing cone*

If immediate removal of the standing cone would compromise blood supply, its excision may be delayed until the flap has integrated into the recipient site (usually around 3 to 4 weeks). The need to delay standing cone removal is most likely for flaps whose large arc of rotation forms a standing cone that encroaches on the vascular pedicle (Fig. 23-28).



A



B



C



D

Figure 23-28. Staged excision of the standing cone to maximize blood supply to a trilobed flap. (A) Mohs defect. (B) Trilobed flap design. The pedicle encroaches on the vascular pedicle. (C) Immediate postoperative appearance. The standing cone was left in place, resulting in a contour deformity. (D) Appearance after staged excision of standing cone.

2. Combining transposition flaps with other reconstructions

Large surgical defects may require a combination of a transposition flap and another flap or graft. The additional reconstruction may be necessary to help cover the primary defect or the secondary defect after transposing the flap (Fig. 23-29).



Figure 23-29. Multisubunit defect (cheek and ear) repaired with a rhombic flap and full-thickness skin graft. (A) Mohs defect. (B) Rhombic flap design to cover cheek subunit. (C) Rhombic flap sewn into place. (D) A Burow's graft was used to cover the ear subunit. (E) Immediate postoperative appearance. (F) Six-month follow-up.

COMPLICATIONS

Pincushioning, or trapdoor deformity, may occur with transposition flaps, especially on the nose. Several etiologies have been suggested, such as excessive flap thickness, inadequate undermining, and circumferential wound contraction. Strategies to minimize pincushioning include appropriately sizing the flaps, careful suturing of all anatomic layers, and closing any dead space under the flap. Contact inhibition of the pincushioning effect may be accomplished by assuring that the undersurface of the flap is sutured to the defect; a flap that is kept in contact with the wound bed may have a decreased tendency to pincushion. These buried quilting or basting sutures do not need to be tacked to deeper immobile structures, as is performed with suspension sutures, since the goal is to maintain the contact of the flap base with the underlying defect, not to recreate a natural sulcus. The vascular supply to the flap should never be compromised, however, by overly zealous attempts at contact inhibition. If intralesional corticosteroids do not resolve pincushioning, surgical thinning may be necessary.

The curved lines that result from most transposition flaps require meticulous suturing, as they rarely fall along cosmetic subunit junctions or relaxed skin tension lines. This attention to detail is particularly critical for successful execution of flaps on sebaceous skin, such as the distal nose.

Transposition flaps that span multiple facial subunits may ablate cosmetic subunit junction lines. Patients may be prepared for the possibility of staged reconstruction to restore a concave subunit junction, such as the alar groove or melolabial fold ([Fig. 23-30](#)).



Figure 23-30. Transposition flaps that span multiple subunits may ablate cosmetic subunit junction lines. Perioral Mohs defect (A) repaired with an inferiorly based rhombic flap (B). The primary lobe of the flap interrupts the melolabial fold and is apparent immediately postoperatively (C). Appearance prior to revision (D). After staged reconstruction to recreate the melolabial fold (E).

When recruiting tissue from distant sites, transposition flaps may not match the contour, texture, and hair density of the defect. For example, when recruiting from an area with substantial fat, such as the cheek, to cover an area with minimal subdermal fat, such as the lip, a bulky flap is expected (Fig. 23-31). Surgeons may counsel patients when additional procedures, such as staged surgery or hair removal, are anticipated (Fig. 23-32).



A



B



C



D

Figure 23-31. Staged reconstruction may be anticipated when recruiting from distant sites. Upper lip Mohs defect (A) repaired with a bilobed flap which recruits skin from the cheek. (B) Immediate postoperative appearance. Note the ablation of the melolabial fold and bulkiness of the primary lobe,

which contains substantial fat. (C) Prior to revision. (D) Appearance after staged reconstruction to recreate the melolabial fold and debulk the primary lobe.

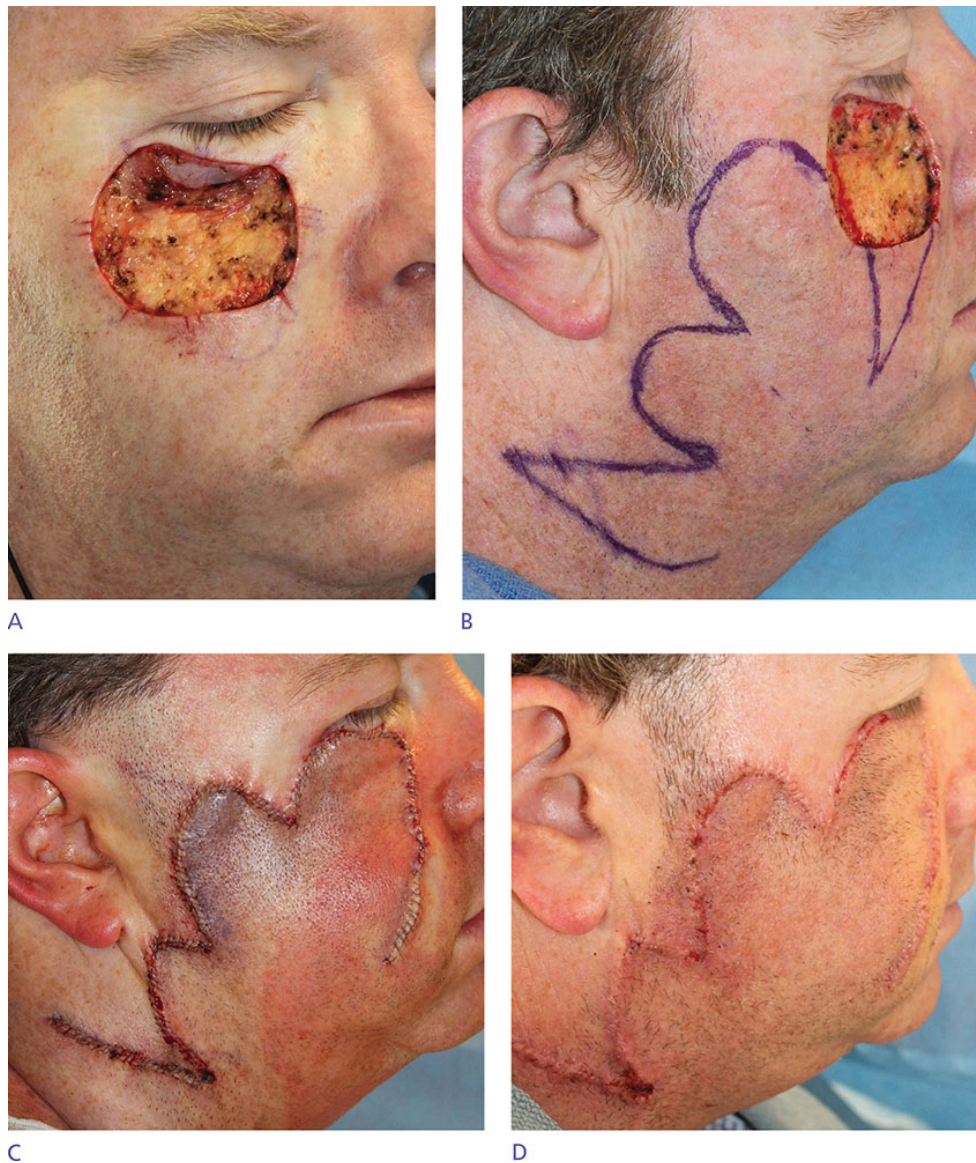


Figure 23-32. When recruiting tissue from donor sites with a different hair density than the defect, patients may be counseled regarding the need for hair removal procedures (such as shaving or laser hair removal) at the recipient site. (A) Mohs defect on the right lower eyelid and infraorbital cheek. (B) Trilobed flap design containing terminal hairs. (C) Immediate postoperative appearance. Note the transposition of the dense terminal hairs that are even more apparent at the 1-week follow-up (D).

CONCLUSIONS

Transposition flaps enable displacement of tension to a more favorable location and recruitment of tissue from adjacent and distant tissue reservoirs. They can be used to repair defects in nearly any area of body, especially in locations where preserving the position of free margins and restoring contour at the primary defect are of paramount importance.

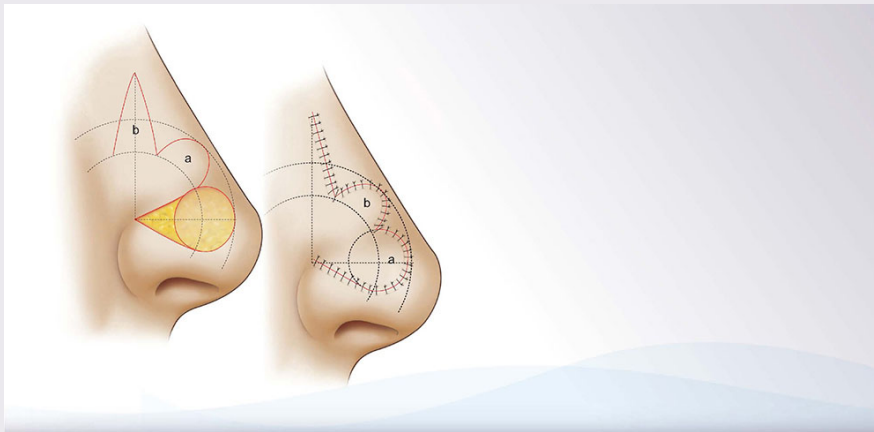
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CHAPTER 24 Bilobed Flaps

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SUMMARY

- Over the past two decades, the bilobed flap has become a workhorse technique for nasal reconstruction.
- While often conceptualized as a transposition flap, it has a significant rotational component and also incorporates a Z-plasty, making it a powerful technique for nasal reconstruction and beyond.

Beginner Pearls



- To minimize the risk of distortion, the width of the secondary lobe, primary lobe, and primary defect are all designed to be of equal size, though some authors have suggested adopting undersized primary and secondary lobes.
- Laxity of the medial cheek and nasofacial sulcus skin is recruited when closing the tertiary defect, permitting a tension-free closure.

Expert Pearls



- A prototypical bilobed flap on the nose involves several unique features:
 - Greater movement about the pivot point because of its position near the recruitable medial cheek
 - Double transposition design displacing the tension vector away from the primary defect
 - Lengthening effect of the Z-plasty to overcome pivotal restraint
 - Less than 45 degrees of transfer between each lobe to minimize standing cone deformity.

Don't Forget!



- Always orient the tertiary defect vertically, as any diagonal vector may cause elevation of one of the alar rims.
- The flap can be drawn freehand by imagining two hearts overlapping, which inherently creates lobes of equal width and length.
- Meticulous suturing technique is a must for minimizing the appearance of curvilinear scars.

Pitfalls and Cautions



- Extranasal bilobed flaps may have more of a tendency to pincushion than those on the nose.
- Deepen the defect on the nose to the cartilage, making room for the incoming flap. This will prevent additional bulk adding to the temporary trapdooring or edema.

Patient Education Points



- As with all flaps, warn patients that the length of the suture lines will be significantly longer than the defect.
- Always advise patients that they may have a multi-stage procedure, and that trapdooring is likely to occur. Patients will be much more understanding regarding the need for intralesional steroid injection or other intervention if they were prewarned that this may occur.

Billing Pearls



- Flap repair codes (140XX series) include the excision component, so it is not appropriate to bill both an excision and a flap repair code simultaneously.
- Mohs codes may be submitted along with flap repair codes, though they may be subject to the multiple- procedure reduction rule.
- When coding a flap, medical necessity is the ultimate arbiter of appropriateness.

CHAPTER 24 Bilobed Flaps

INTRODUCTION

Over the past two decades, the bilobed flap has become a workhorse technique for nasal reconstruction. While often conceptualized as a transposition flap, it has a significant rotational component and also incorporates a Z-plasty, making it a powerful technique for nasal reconstruction and beyond.

HISTORY AND EVOLUTION OF THE BILOBED FLAP

Although classified as a double transposition flap, the bilobed flap was actually described *before* the classic single transposition rhombic flaps of Limberg¹ and Defourmentel.² The original design is attributed to Esser, who published its use in 1918 for nasal tip defects (Fig. 24-1).³

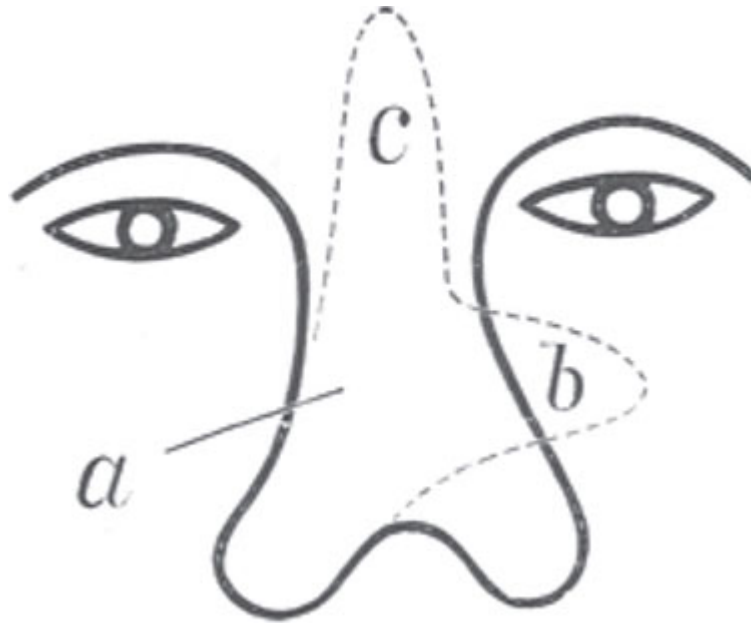


Figure 24-1. Original Esser design.

According to Esser's initial design, the angle of tissue transfer between each lobe of the flap was 90 degrees.³ The total transposition thus took place over 180 degrees, as it relied on the nasal dorsum tissue to cover defects on the nasal tip. This large degree of rotation forced the lobes to be relatively wide, resulting in an obvious standing cone deformity around the pivot point. Thus, this flap technique, published in German, went largely unnoticed for at least three decades.

In 1953, Zimany revisited the flap and expanded its application to defects on the trunk and soles.⁴ In 1981, McGregor and Soutar noted that the angle of tissue transfer could be varied from the original 90 degrees for each lobe.⁵ Indeed, in their study, the average angle of transfer was only 108 degrees. They also highlighted both the rotational and transpositional components of the flap.

In 1989, Zitelli published three modifications that would make the bilobed flap among the most commonly used flaps for defects on the lower nose.⁶ The first improvement was formally narrowing the angle of transfer to a maximum of 45 degrees between each lobe. This decreased the total angle of transfer to no more than 90 to 110 degrees. The second modification was to insert a Burow's triangle between the primary defect and the pivot point. Intentional design and removal of standing cones upfront were personal preferences of

Zitelli. These two changes eradicated prominent tissue protrusion around the pivot point. Finally, he advocated wide undermining of the flap and surrounding tissue to reduce pincushioning. Shortly thereafter, Burget confirmed excellent results using these design modifications on the nose.⁷

PRINCIPLES OF THE BILOBED FLAP

Advantages of the bilobed flap

The nose presents several reconstructive challenges. The topography is complex with multiple convex and concave surfaces that must be maintained. The alar rims are mobile free margins, and are easily displaced. The skin over the lower third of the nose also has limited mobility, and generally cannot be recruited for more than the narrowest primary closures or advancement flaps. Finally, retaining the function of the nose and nasal valves is paramount.

The bilobed flap is thus particularly suited for reconstruction on the distal nose, as it enables the surgical site to be filled with nearby skin of similar color and texture, while concomitantly leaving the free margin and airway remains undisturbed, as all tissue movement and tension are concentrated on closing the tertiary defect on the nasal dorsum.

Design principles

To minimize the risk of distortion, the width of the secondary lobe, primary lobe, and primary defect are all designed to be of equal size (Fig. 24-2). To facilitate closure, the secondary lobe may be slightly narrower when it is located on relatively immobile skin adjacent to the medial canthus. Some authors have suggested adopting undersized primary and secondary lobes.⁸ This approach can be considered if there is considerable tissue laxity around the primary defect.

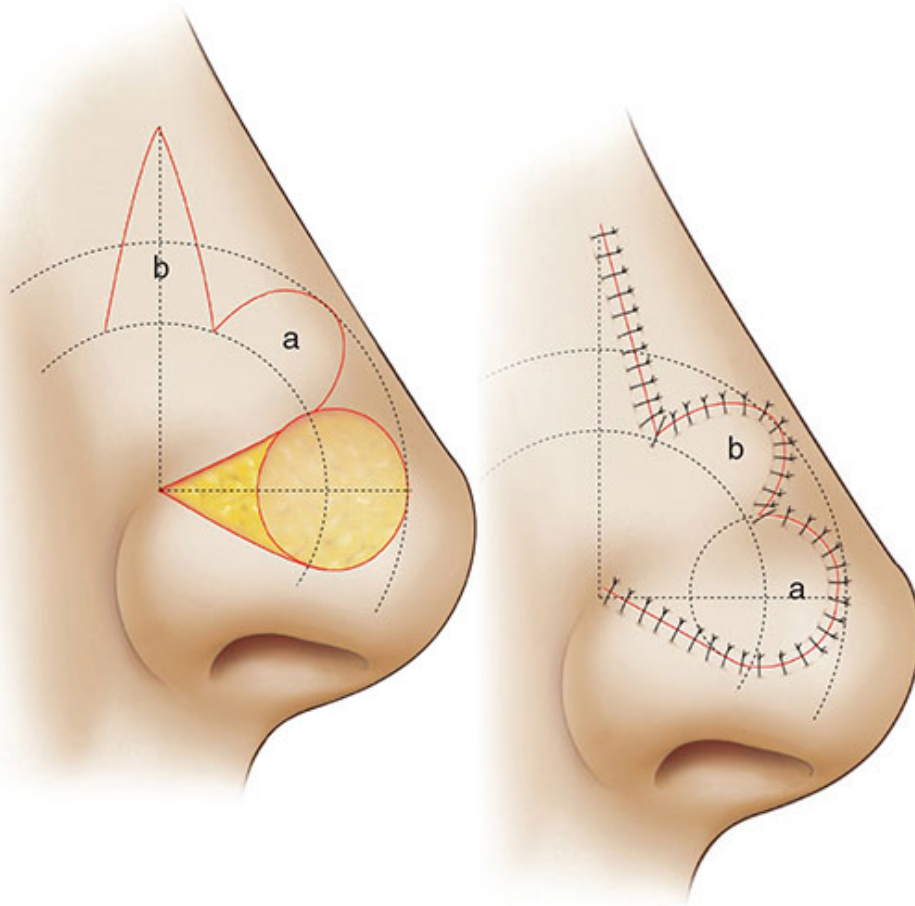


Figure 24-2. Zitelli modifications of the bilobed flap. Decreased angle of tissue transfer and incorporation of a Burow's triangle reduces standing cone deformity. The apex serves as a focal point for the design. Each donor lobe is designed around one arc through the center of the defect, and another arc through the distal end of the defect.

If the flap is meticulously designed so that the lobes of the flap equal the width of the defect, then virtually all of the flap's tension is in closing the tertiary defect. This is analogous to a standard transposition flap closure, where the key suture—and attendant tension—is in closing the secondary defect. As such, the bilobed flap's tertiary defect should be oriented vertically. Any diagonal vector to this final defect may cause elevation of one of the alar rims.⁹

The ideal defect for the bilobed flap is small (less than 1.5 cm) and located on the lateral nasal tip or distal nasal sidewall. When performed in this location, the skin laxity of the medial cheek and nasofacial sulcus is recruited when closing the tertiary defect. In theory, however, defects of any size and in any nasal location may be repaired with a bilobed flap, as long as

the flap can be drawn entirely on the nose with the final lobe pointing superiorly. The upper limit of a defect amenable to this procedure is contingent on the size of the patient's nose, the location of the defect on the nose, and the elasticity of the nasal bridge skin. Limitations of the bilobed flap—or, at least, a realization that there is less room for error—become evident when defects are larger or arise within rigid sebaceous skin.¹⁰

Biomechanics

At the first glance, the bilobed flap appears to be a modified rotation flap with some component of transposition. However, during the movement of tissue, there is a greater release of tension than would be expected with rotation alone. The mechanical release of tension is due to the Z-plasty that is inherent within the flap's design.^{11,12} The lengthening effect of the Z-plasty overcomes the otherwise significant pivotal restraint, enabling the primary defect to be repaired without tension.

A prototypical bilobed flap on the nose involves several unique features: greater movement about the pivot point because of its position near recruitable medial cheek, double transposition design displacing the tension vector away from the primary defect, lengthening effect of the Z-plasty to overcome pivotal restraint, and less than 45 degrees of transfer between each lobe to minimize standing cone deformity.

The bilobed flap: step-by-step

Basic steps for execution of the standard bilobed flap for the repair of a defect on the distal third of the nose are outlined here. Ideal angles have been calculated for a perfect design of the flap.^{13,14} However, the flap can be drawn freehand by imagining two hearts overlapping, which inherently creates lobes of equal width and length (Fig. 24-3).



Figure 24-3. Series of photos for standard bilobed flap on the distal nose. (A) Basal cell carcinoma. (B) Postexcision using Mohs technique. (C) Bilobed flap design. (D) Immediately postrepair with bilobed flap. (E) Three months postoperative. (F) Six months postoperative. Note the mild pincushioning present at the 3-month follow-up that resolved spontaneously. Dermabrasion or scar revision was not utilized.

Step One. Design and draw the bilobed flap. First, draw a long and narrow Burow's triangle from the surgical defect to the apex of the flap. If possible, the superior edge of the Burow's triangle is parallel to the alar crease. The apex should be positioned just above the alar crease, so any residual standing cone does not raise this concavity. The apex serves as a

focal point for the rest of the design. Each donor lobe is designed around one arc through the center of the defect and another arc through the distal end of the defect. Each lobe's radius is positioned approximately 45 degrees from the other, and 45 degrees from the defect.

Step Two. Excise the Burow's triangle. Debevel and remove any remaining subcutaneous tissue from the primary defect. Deepening the defect is preferable to thinning the flap. Adipose can safely be trimmed beneath the pivot point to prevent tissue redundancy.

Step Three. Incise and lift the flap. Undermine widely beneath the flap and surrounding tissue in the submuscular plane, just above the perichondrium or periosteum. Undermine the fibrous tethers along the lateral sidewall, at the junction of the nasal bone and the upper lateral cartilage. This releases the skin and allows recruitment of loose medial cheek skin. Thin the distal-most edge of the primary lobe so that it does not add bulk to the alar rim. The flap thickness should be slightly thinner than the depth of the defect.

Step Four. Precise hemostasis. Avoid electrodesiccation of the lobule tips, the areas most at risk for necrosis. Electrodesiccation of the epidermis and dermis is not necessary.

Step Five. The first stitch or "key stitch" closes the tertiary defect. Closure of the tertiary defect should be exactly horizontal, or unwanted displacement of the alar rims and medial canthi may ensue. After closing the tertiary defect, the flap should easily drape into place without tension. If a gap is visible, it is due to the primary wound gaping, and resolves when the tissue is brought back to its baseline position. The next suture usually connects the inferior distal edge of the primary lobe to the primary defect near the medial alar rim. Alar rim position is assessed before suturing the remainder of the flap.

Step Six. Trim the secondary lobe to fit the secondary defect, and close the remaining wound edges in a layered fashion. Meticulous buried vertical mattress stitches are essential to create an epidermal seal and reduce visible lines. Ensure that all layers of the wound edges are approximated, and carefully pull together any dermis or muscle that may have retracted away from the wound edge.

Step Seven. Bandage the wound in a standard fashion with a 24-hour pressure bandage. Counsel the patient to expect mild edema of the distal

portion of the flap in around 1 to 2 months; this should resolve with massage and time. If pitting along the surgical line develops, the patient may return in 2 months or later for dermabrasion.

MODIFICATIONS OF THE BILOBED FLAP

Trilobed flap

The most common variation on the bilobed flap is the trilobed flap. When faced with a defect where there is little tolerance for tension on the surrounding skin, a bilobed should be considered; when a bilobed design presents challenges, consider the trilobed flap (Fig. 24-4).¹⁵

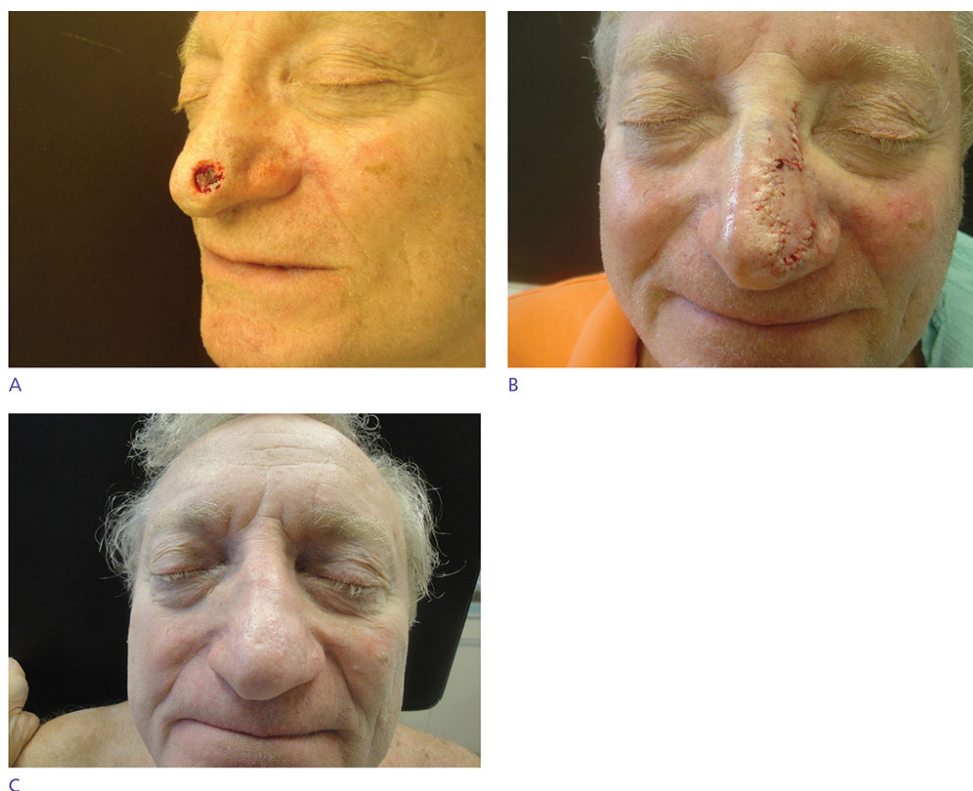


Figure 24-4. Series of photos for trilobe flap on infratip. Mohs defect (A), immediately postrepair (B), and 3 months postoperative (C).

A trilobed flap may be a viable option for distal nasal defects, such as those on the infratip. Beginning at the defect, draw similarly sized lobes until the final lobe is pointing exactly vertically. Though the additional lobe will

cause the total angle of flap transfer to increase, each lobe is only rotating 45 degrees or less. Therefore, a trilobed flap does not cause any additional standing cone deformity around the pivot point.

A trilobed flap with a diminutive vertical Burow's triangle has been reported for defects on the medial ala; however, a very short Burow's triangle with its apex in the alar crease could theoretically lead to nasal valve constriction.¹⁶ A quadrilobed flap has also been described, again for distal tip defects.¹⁷ In these cases, however, a medially based bilobed flap (as discussed below) may be a more straightforward option.

Medially based bilobed flap

When the defect appears too big for a bilobed flap, consider drawing the flap with the Burow's triangle oriented medially, rather than laterally (Fig. 24-5).¹⁸ A contralateral or medially based bilobed flap is an easy solution for a large and deep defect, and for select small distal alar defects.¹⁹ Although the vascular supply is not as rich in these locations, due to an increased distance from the angular artery, medially based bilobed flaps are reliable. Importantly, design the flap with sufficient lobe length to accommodate draping over the convex midline. As with all large bilobed flaps, assure that there is adequate laxity on the upper two-thirds of the nose to permit closure of the tertiary defect.



Figure 24-5. Series of photos for medially based bilobed flap. Mohs defect too large for standard bilobed flap (A), immediately postrepair (B,C), and 3 months postoperative (D,E),

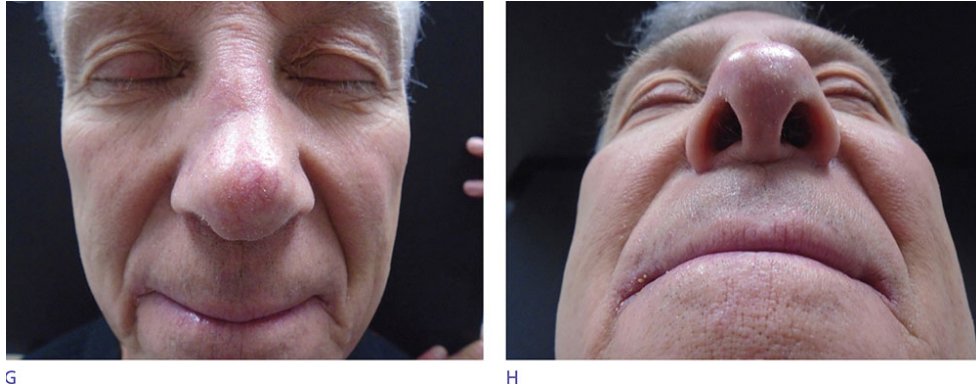


Figure 24-5. and 6 months postoperative (F–H).

Bilobed flap for two defects

The bilobed flap can also be used to repair two nearby defects, especially when the flap is designed so that the second defect lays in the area representing the nascent Burow's triangle.²⁰ The design of the Burow's triangle can thus be elongated to provide coverage for a smaller defect inferolateral to the first.

Lengthening the primary lobe

Lengthening of the primary lobe of the flap to overcome pivotal restraint has been described as a strategy to better reach the distal edge of the primary defect and overcome pivotal restraint.²¹ The defects described in this report, however, were not the typical size or in the usual location for a bilobed flap.

When the bilobed flap is used to repair a defect on the nasal tip, the flap will naturally recruit skin from the medial cheek and nasofacial sulcus, obviating the need for an oversized primary lobe. Still in cases where the flap is large, so that closure of the tertiary defect causes tension near the medial canthus, a longer primary lobe may be useful.

Another strategy to mitigate the challenges of pivotal restraint is to design a long and narrow Burow's triangle, approximately 1.5 times the diameter of the defect. If the Burow's triangle is significantly shorter, as can occur by necessity with larger defects, pivotal restraint may present a greater challenge.²²

Hinge flap and supporting framework

The relatively thick bilobed flap, with its underlying muscle and relatively firm skin, coupled with little to no tension on the primary defect, enables most closures to be performed without the use of cartilage grafts. For full-thickness through-and-through defects, epidermis from the Burow's triangle can be hinged over on a muscular pedicle to restore missing mucosa.

Alternatively, the epidermis and dermis can be excised, leaving muscle to be flipped in to fill a deeper defect. Cartilage struts can also be used to restore structure or support the alar rim, especially at the soft triangle that can be prone to notching. Following these deeper approaches, a standard bilobed flap can be executed for cutaneous cover.

SPECIAL LOCATIONS AND APPLICATIONS OF THE BILOBED FLAP

Chin

The key advantage of all transposition flaps is reorientation of the tension vector. In a bilobed flap, the tension vector is not only reoriented, but also distant to the defect. This enables closure of the primary defect without any tension, making it a reliable solution for defects near any free margin. As such, the bilobed flap can be used on the chin without fear of displacing the lower lip or commissure, with the added benefit of bringing in matching skin with terminal hair. Undermining is performed within the mid-adipose plane, with special care taken along the mandible where the marginal mandibular nerve is located. After completion, the straight line from closure of the tertiary defect should lie along a relaxed skin tension line, such as the marionette fold. The point of the final lobe is tucked beneath the chin to avoid a standing cone deformity at the mandible that would unilaterally accentuate the jowl (Fig. 24-6).



Figure 24-6. Series of photos for bilobed flap on chin. Mohs defect (A), immediately postrepair (B), and 6 months postoperative (C).

Lateral nasal bridge

Usually a rhombic flap will suffice here. However, a bilobed flap can also be used, with closure of the tertiary defect camouflaged within a glabellar fold.

Periorbital region

Again, the bilobed flap can be used without fear of pulling on the lid margin or lateral canthus. A superiorly based design has been reported to guarantee no downward pull on the lower lid.^{23,24}

Large or horizontally oriented cheek defects

On the cheek, the bilobed flap is useful when rotation flaps will not provide enough tissue coverage (Fig. 24-7). This occurs when the defect is large and located on the mid-cheek, away from the central face. In this location, the amount of remaining cheek skin available may be insufficient to fill a large cheek defect.²⁵ Additionally, a hinge-over of subcutaneous tissue from the Burow's triangle can be used to fill a very deep defect, and a suspension suture can be used to anchor the flap to the zygoma, if needed. Similarly, horizontally oriented defects on the cheek may be closed with a bilobed or trilobed flap that may confer the added advantage that they will be smaller than a rotation flap for a similarly sized defect.



A



B



C



D



E

Figure 24-7. Series of photos for a bilobed flap on cheek. Large melanoma in situ (A), defect with insufficient lateral cheek reservoir for rotation flap (B), immediately postrepair (C), 3 months postoperative (D), and 1 year postoperative (E).

Helical rim

The bilobed flap has limited utility on the ear as there is a dearth of mobile skin available for recruitment. The flap may be utilized for select helical rim defects, particularly when the final lobe can be drawn to recruit skin from the postauricular sulcus. While acceptable results have been published, free grafts, helical rim advancement flaps, or pedicle flaps may be more useful in this location.

Other locations

Other published locations for reconstruction with the bilobed flap include small alar rim defects,²⁶ full-thickness alar defects,^{27,28} upper lip,²⁹ axilla, digits, perineum, extremities, and feet.³⁰

FINESSING THE BILOBED FLAP

Initial design

The key to success of any flap is precise design. The lobes should be equal in width to that of the defect. Deviation from this will induce movement in the skin and subcutaneous tissue surrounding the primary defect. On the nose, lobes should be drawn until the final lobe is directed completely vertically. Off the nose, closure of the tertiary defect should be along relaxed skin tension lines. In all locations, closure of the tertiary defect should utilize existing laxity, and not cause distortion of surrounding tissue.

Importantly, bilobed flaps on extranasal locations do not include muscle; therefore, by definition, they have a less robust vascular supply than seen on the nose. Though Cook has recommended an inferiorly based pedicle to facilitate drainage and decrease pincushioning,³⁰ the location typically dictates the orientation of the flap: the flap should be designed so that closure of the tertiary defect results in a line along relaxed skin tension lines. [Table](#)

24-1 is a summary of common pitfalls and remedies regarding the use of bilobed flaps.

Table 24-1. Common Pitfalls and Remedies

Problem	Considerations
Distorted alar rims, alar asymmetry	Be sure the secondary lobe is oriented exactly vertically, and all stitches closing this tertiary defect are horizontal, so that there is no upward pull of either ala. Also, design the primary lobe to be the exact width and length of the primary defect to eliminate movement around the primary defect.
Ipsilateral alar rim depression	Anticipate this bulldozing effect with thick sebaceous skin or when employing large angles of transposition. Slightly trim the primary lobe of the flap to compensate.
Tip necrosis	Careful pinpoint hemostasis especially near lobule tips. Do not electrodesiccate the epidermis or dermis. If tip necrosis does occur, this is usually superficial and occlusive dressings will allow the necrotic area to fill in.
Trapdooring of distal-most portion of flap	Undermine both the flap and defect widely. Remove any remaining subcutaneous tissue from the defect. Avoid “stuffing” the flap into the defect. Intralesional triamcinolone postoperatively may be helpful.
Webbing of medial canthus	Undersize the final lobe of the flap if needed. Closure of the final lobe on the nasal bridge should be with stitches that are exactly horizontal. Do not pull diagonally on any tissue, particularly near the medial canthi.
Primary lobe of flap does not reach or adequately cover the primary defect	If large flap or crossing convexity, consider measuring with a suture or adding an additional 1 mm of length to flap design. Undermine fibrous attachments at nasofacial sulcus to release more tension.
Bilobed flap does not fit on the nose	Consider a medially based bilobed. Avoid a bilobed or trilobed flap with pivot point on the nasofacial junction or crease.
Secondary lobe does not point perfectly vertical	Either draw a tertiary lobe so that the final lobe is pointing exactly vertically, or move the apex inferiorly to “tilt” the bilobed flap.
Standing cone at pivot point	Make Burow’s triangle longer so that angle of transposition between each lobe is 45 degrees or less. Also, debulk fat from beneath the pivot point.

Flap execution

First, deepen the defect on the nose to the cartilage, making room for the incoming flap. This will prevent bulk adding to the anticipated temporary trapdooring or edema. The fat directly beneath the pivot point can safely be debulked to further prevent a standing cone deformity.

Detaching the fibrous attachments of the skin from the bony structure of the nose will allow the flap to mobilize and reach as predicted. There are prominent attachments on the mid-nasal sidewall over the attachment of the nasal bone to the upper lateral cartilage. When the flap is undermined at the level of the periosteum, the fibrous bands are released, and skin can be recruited from the medial cheeks to reduce tension on the closure. These fibrous attachments can be released on both sides of the nose.

One disadvantage of this flap is the use of multiple small curved lines that do not follow preexisting skin folds or wrinkles. In theory, one could design a double rhombic flap about a single pivot point with angular lines, or modify each lobe to have pointed tips.¹³ Both of these designs still require the use of multiple short lines in various directions. Fortunately, sutured lines

can be barely noticeable if precise suturing techniques are employed. It is imperative to use deep buried sutures to pull the retracted subcutis and muscle of the flap back to its original position along the suture line. Failure to pull this retracted tissue back to the suture line results in excess tissue under the flap, which can contract and contribute to pincushioning. This can also result in depressed suture lines that are difficult to remove with dermabrasion.

Displacement of the alar rim

The main reason for any inferior displacement of the ipsilateral alar rim is the lengthening effect of the Z-plasty. Larger angles in a Z-plasty result in greater gains in length.⁹ Thus, bulldozing is most likely to be encountered when employing larger flaps that require commensurately larger angles, and pivot within less mobile skin.¹² Since this inferior displacement is noticeable intraoperatively, the first sutures on the primary lobe can be adjusted, or the primary lobe of the flap can be trimmed. Minor displacement of the alar rim usually corrects itself by 6 weeks.¹³

Persistent erythema

Mild erythema along the suture lines is not uncommon, and spontaneously resolves by 1 month. However, persistent erythema may occur, particularly in patients with rosacea or fair skin. Neovascularization or telangiectasias may also occur in high-tension wound closures.¹⁰ These take longer to resolve, and pulsed-dye laser or intense pulsed light may be helpful.

Trapdooring and pincushioning

Undermining widely will reduce the focal scarring that can cause trapdooring or pincushioning of the inferior-most portion of the flap. Undermining to the nasofacial junction bilaterally encourages a more uniform and platelike contraction of the entire lower nose. This reduces the “puffiness” of the flap relative to the surrounding skin.

Furthermore, assure that the flap thickness matches that of the defect. This can be achieved by removing any remaining subcutaneous tissue from the

defect, and, if necessary, trimming fat from the incoming flap. The flap should be flush or slightly lower than the surrounding skin immediately postoperatively. At that point, any edema that develops around week 4 can be confidently diagnosed as simply edema due to the dependent location of the primary lobe. The patient can be reassured that this will resolve with massage and time. Infrequently, small volumes of intralesional triamcinolone may be injected to improve the scar-associated edema.

Medial canthus distortion

Infrequently, unexpected rigidity of the nasal bridge skin may be encountered, even when the patient denies previous surgery in the area. Closure of a wide tertiary defect can occasionally cause distortion of the medial canthus. This can usually be avoided by accurately assessing the degree of skin laxity prior to design, drawing the secondary lobe slightly narrower than the primary lobe, and making sure all sutures in this area are oriented precisely horizontally.

Dermabrasion

Postoperative dermabrasion is helpful in approximately one-third of cases. This can remedy any residual pits that may develop on sebaceous or rhinophymatous noses. Dermabrasion can be performed 6 weeks to 3 months postoperatively, or even later if desired.

First, hypertrophic areas are marked with a pen prior to anesthesia. Second, hypertrophic sebaceous hyperplasia surrounding the surgical lines is tangentially shaved, holding the scalpel almost parallel to the skin surface. Finally, sterilized 80-grit sandpaper is used to smooth the entire cosmetic unit. Patients apply petrolatum ointment and a nonstick bandage daily for 2 weeks, and are counseled not to allow the wound to develop a scab.

CONCLUSIONS

The bilobed flap provides a unique approach to nasal closures, as it combines the benefits of a rotation flap, transposition flap, and Z-plasty. With meticulous attention to design and execution, this technique can represent a

fundamental approach to closures on the lower nose and, occasionally, elsewhere on the head and neck.

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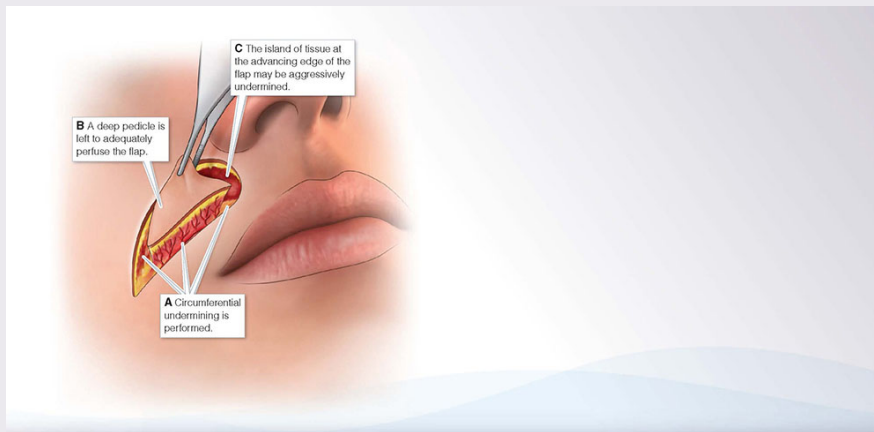
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CHAPTER 25 Island Pedicle Flaps

H. William Higgins
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SUMMARY

- The V-Y island pedicle flap permits a triangular island of tissue to be advanced into a defect.
- The flap relies on a robust vascular pedicle, and when properly designed is an effective technique for numerous defects.
- The chief disadvantage of this approach is the increased risk for trapdooring and resultant undesirable scarring.

Beginner Tips



- Island pedicle flaps are frequently used on the lip, as their triangular scar line may be camouflaged within cosmetic subunit boundaries.
- The fully circumferential suture lines and increased risk of trapdoor phenomenon mean that attention to detail in suturing techniques is of vital importance to camouflage the scar as effectively as possible.

Expert Tips



- Basting sutures at the base of the flap may help mitigate the risk of the trapdoor phenomenon, though care should be taken to avoid restricting blood flow to the pedicle.
- In general, island pedicle flaps should be undersized relative to the defect size.

Don't Forget!



- Undersizing island pedicle flaps means that there may be a significant component of secondary motion. This needs to be accounted for in order to avoid tissue distortion.
- Island pedicle flaps are not purely advancement flaps; they may be rotated or transposed into place as well.

Pitfalls and Cautions



- Even though island pedicle flaps benefit from a robust vascular pedicle, they should be used with caution in smokers, who may have an increased risk of necrosis.
- Always tailor flap design to the individual patient; flap elevation and undermining in patients on aspirin or other anticoagulants may increase the risk of hematoma formation.

Patient Education Points



- Patients should be warned prior to flap closure that they will have an incision stretching well beyond the initially visible defect.
- Always advise patients that they may have a multistage procedure, and that trapdooring is likely to occur. Patients will be much more understanding regarding the need for intralesional steroid injection or other intervention if they were prewarned that this may occur.

Billing Pearls



- Flap repair codes (14040 and 14060 series) should be used for V-Y island pedicle flaps, and include the excision component, so it is not appropriate to bill both an excision and a flap repair code simultaneously.
- Island pedicle flaps should not be coded with 15740, as this requires identification and dissection of a named axial vessel.

CHAPTER 25 Island Pedicle Flaps

INTRODUCTION

Defects on cosmetically sensitive locations of the head and neck require delicate reconstruction to preserve anatomic function while also providing satisfying cosmesis to the patient.¹⁻³ Options for repair range from second intention healing to complex surgical reconstruction. When chosen appropriately, flaps can provide excellent cosmesis and outcomes.⁴⁻⁶

Prior to flap repair, the surgeon should ensure that the tumor has been resected completely with clear histologic margins. Using flaps to repair the defect rearranges surrounding tissues, making it difficult to locate tumors if they recur. An incompletely excised recurrent tumor may be disguised by the flap, delaying appropriate diagnosis, which may result in increased morbidity. The rearranged tissue planes produced by the flap can also make tumor extirpation more challenging, leading to more complex surgery to remove the remaining tumor.

Once the tumor has been removed with clear histologic margins, the surgeon can consider a range of reconstructive options. A well-designed and properly executed flap provides reconstructive advantages, providing a viable vascular supply to the defect while maintaining function with minimal morbidity. The variability in skin flaps available for each type of defect requires an experienced surgeon to possess an extensive knowledge of facial anatomy, tissue motion, and reconstructive options offering the best soft tissue repair.⁷

FLAP CHOICE AND CONSIDERATIONS

After extirpation of the tumor, the defect should be examined with respect to the cosmetic units involved.⁷ Repairs that respect cosmetic units and stay within these boundaries often produce the best results. Defects that traverse more than one cosmetic subunit should ideally be repaired individually, instead of using a single repair method that crosses multiple units.^{8,9}

Flaps are typically categorized based on the type of movement involved, such as advancement, rotation, transposition, or interpolation; or by the blood supply pattern, for example, random or axial. Random pattern flaps are supplied by dermal vasculature, while axial pattern flaps are supplied by named vessels; the former are more frequently performed in dermatologic surgery.

Description of the V-Y island pedicle flap

The island pedicle flap, also referred to as the V-Y advancement flap, is a specialized type of advancement flap. This modified advancement flap uses a triangular or V-shaped section of skin to repair the primary defect. With the flap in place, the resulting incision lines appear in the shape of a Y. When creating the flap, a triangular shaped skin segment is completely separated from surrounding skin, creating an island. Despite being detached from surrounding structures, an underlying supply of rich vasculature embedded in the subcutaneous tissue remains intact, forming a pedicle.

This repair is a valuable and versatile tool for use on head and neck defects. Its rich vascular pedicle, combined with the enhanced mobility of the island, makes it a workhorse flap for many small- to medium-sized defects in cosmetically challenging areas of the face. It is unique in that its vascular supply relies entirely on the underlying pedicle, as all epidermal and dermal margins are severed when creating the island. Subsequently, the triangular island can be advanced as far as the underlying mobility allows. This unique characteristic allows the surgeon to take advantage of neighboring tissue reservoirs with more freedom than a traditional advancement flap, in which motion is restricting by the adherent margin of the flap (restraint).

The single-stage repair also offers predictable aesthetics with minimal morbidity or operative risk. This flap was initially described for use on cutaneous defects of the forehead, eyebrow, nasal dorsum, cheek, and upper cutaneous lip. Modified versions of this flap have also been used to

reconstruct challenging defects of the ear, medial canthus, nasal ala, and nasal tip.^{10–18} Because the resulting flap leaves a tail-shaped outline, analogous to the lower half of a Y, the incision lines of the flap can often be hidden along contour lines, rhytides, or cosmetic subunit boundaries.

Comparison to traditional advancement flap

Traditionally, the mechanics of an advancement flap require that it have a length-to-width ratio of approximately 3:1. This allows for adequate perfusion of the entire flap, as well as optimizing wound tension. Flaps exceeding this ratio have a higher risk of distal necrosis due to poor perfusion. This ratio can be limiting in certain situations, as the surgeon must choose between widening the width of the flap to accommodate the length, with resulting worsening cosmesis, or lengthening the flap without changing the width, with risk of distal necrosis.^{14,15,19}

As with classic advancement flaps, the island pedicle flap has a tension vector that is parallel to the direction of the flap. Like all flaps, the tension caused by advancement of the island pedicle can lead to secondary movement of the skin distal to the flap. This secondary movement is important to consider, as it can lead to distortion of cosmetic unit boundaries or altered anatomic function in areas such as the eyelid margin or nasal ala.^{14,15,19}

Advantages of the island pedicle flap

Compared to other random axial flaps or traditional advancement flaps, the island pedicle flap has several advantages (Table 25-1). The pedicle provides an excellent vascular supply, as it relies on the rich subcutaneous plexus. In contrast, other flaps depend on dermal anastomoses and are thus at higher risk of necrosis. In the case of a traditional advancement flap, the blood supply originates from the base of the flap, and is dependent on dermal vasculature spanning the entire length of the flap to provide blood supply to the distal edge.^{20,21}

Table 25-1. Advantages and Disadvantages of the Island Pedicle Flap Compared to Traditional Advancement Flaps

Advantages	Disadvantages
Excellent vascular supply from subcutaneous and dermal plexus in the pedicle	Resistance to movement with increased wound tension
Even perfusion pressure throughout pedicle	Increased time for suturing
Decreased risk of flap necrosis	Trapdooring
Decreased need for undermining	Difficult to hide all aspects of the scar within relaxed skin tension lines
No limitation on width to height ratio of flap	Bulkiness of pedicle
Mobility	
Does not require resection of standing tissue cones	

The island pedicle flap is not limited by the 3:1 ratio of advancement flaps, since the vascular supply originates from the rich underlying tissue. Larger flaps can, therefore, be designed with minimal risk of tissue necrosis. Since the subcutaneous tissue supplies the skin evenly, the perfusion pressure is equivalent throughout the pedicle, obviating the traditional increased risk of distal flap-tip necrosis. This reliable blood supply provides a significant advantage compared to other random pattern flaps, and may be a good choice for patients with poor perfusion status, such as chronic smokers, or those with areas of poor vasculature due to prior surgery or radiation in the defect area.

The island pedicle also requires less undermining compared to many other flaps. Since the deep aspect of the pedicle remains connected to the underlying subcutaneous fat, this portion of the flap does not require undermining. This provides an advantage for patients at high risk of bleeding, such as those with thrombocytopenia, bleeding diatheses, or using anticoagulants.

Cosmetically, the tail of the flap can also be incorporating into rhytides or cosmetic subunit boundaries, thereby improving the aesthetic result (Figs. 25-1 and 25-2). For example, in the upper lip area, the tail of the flap produced by closure of the secondary wound can be placed within the fold of the nasolabial groove, providing a minimally noticeable result.²²



Figure 25-1. The flap can be incorporated into cosmetic subunit boundaries.



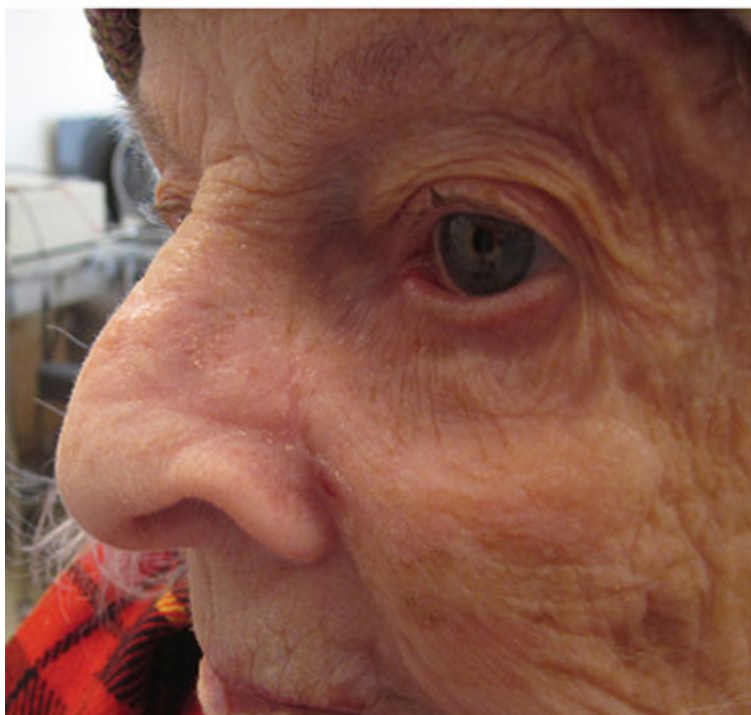
A



B



C





D

Figure 25-2. Even for larger defects, parts of the suture line may be designed to rest along cosmetic subunit boundaries.

Disadvantages of the island pedicle flap

Despite the many advantages of the island pedicle flap, it does have several disadvantages ([Table 25-1](#)). Although the pedicle provides an excellent vascular supply from the subcutaneous plexus, this connection to the deep tissue often results in some resistance to movement. This can increase tension on the flap and also necessitate more reliance on secondary tissue movement. Thus, a pedicle used for large defects will have increased tension at the wound closure site. Using a smaller pedicle allows for decreased tension and improved mobility, but this is offset by the potentially decreased vascular supply of the smaller subcutaneous plexus.

Furthermore, due to the island design, the tissue is incised around the entire margin of the flap. This may increase the risk of trapdooring, which occurs when the flap heals with slight contraction, causing the skin of the flap to rise above the surrounding skin. Trapdooring creates a noticeable and often cosmetically distressing change in skin texture for many patients. This may be ameliorated with dermabrasion, intralesional steroid injection, or surgical revision, though it often improves spontaneously over time.

The incisions of the island pedicle flap also produce a “V” shape, which may make it difficult to hide all of the sides of the flap within natural skin tension lines. In certain locations, such as the upper lip, this task may be easier, with lines along the nasolabial fold, alongside the white roll of the vermillion border, or along the alar crease. In other locations, such as the cheek, this task may be more difficult. This flap also requires meticulous suturing since the entire pedicle is separated on all sides and must be repositioned to fill the defect. Thus, extra time for suturing may be needed for the novice dermatologic surgeon.

Design

Choosing the appropriate wound and location is the first step to success when executing this flap. It is important to assess the amount of mobility that will be produced when circumferential margins of the island are severed. Although this flap can be used for defects ≥ 2 cm in diameter on cosmetically sensitive areas such as the nose or upper lip, the island pedicle flap is typically suited for small- to medium-sized wounds on these areas. The nose has stiff skin and typically lacks the compliance and pliability of other areas such as the cheek. Moreover, due to the curvature of the numerous nasal cosmetic subunits, secondary motion may lead to cosmetically undesirable nasal asymmetry.

Proper design is crucial to the execution and outcome of the island pedicle flap, and allows the surgeon to achieve optimal and reproducible aesthetic results with minimal risk. In general, the flap is designed as an isosceles triangle with two longer edges (the sides) and one shorter edge (the base). The long axis of the flap is ideally placed in relaxed skin tension lines and may be curvilinear to match areas such as the melolabial fold or the vermillion border. This allows the healed incision scars to hide within natural skin folds, making them less cosmetically distressing.

In its classic design, the flap is incised adjacent to the defect and within the same cosmetic subunit (Figs. 25-3 and 25-4). The flap is oriented tangentially away from the defect. The length of the triangular pedicle is usually three to four times the width of the defect, with the apex of the isosceles triangle is angled at roughly 30 degrees. Incisions around the triangular island are made to the level of the subcutaneous fat. The pedicle is also incised with vertical incisions deep to the subcutaneous tissue and may contain muscle or superficial musculoaponeurotic system (SMAS) elements. The surgeon should be comfortable with anatomical variations of structures, and particularly vessels in all layers of the subcutaneous tissue. Even if the flap is overlying a named vessel, this vessel is not dissected with the flap, as the pedicle provides a rich enough vascular subcutaneous plexus to maximize chances of flap survival.



Figure 25-3. Classically, the flap is designed to stay within the same cosmetic subunit.



Figure 25-4. The tail of the flap may ideally be hidden along cosmetic subunit boundaries.

Critically, the flap should be slightly undersized for the defect.¹⁵ Thus, the width of the flap is ideally slightly smaller than the width of the defect. This requires secondary movement of tissue around the defect, but reduces the risk of flap protuberance after it has healed. Basting sutures may also be used to mitigate the risk of trapdoor formation.

The flap is next undermined along the edges, but not at the base of the pedicle. The surrounding skin of the primary surgical defect is also undermined at the same level. The tissue of the pedicle is left intact without excessive undermining to allow for adequate, random pattern perfusion from the subcutaneous plexus. If inappropriately undermined, the flap is at risk of failing due to a compromised vascular supply needed to nourish the tissue. The pedicle itself can contain epidermis, dermis, subcutaneous tissue, fat, muscle, and parts of the SMAS. Undermining of the surrounding edges is performed above the superficial fascia, allowing for adequate movement. This minimizes tension with wound closure and helps to prevent inversion caused by pull at the leading edge. In some areas, such as along the eyelid

margin, the secondary motion created by the flap can cause undesirable functional or cosmetic results, such as ectropion.

After freeing the island, the flap should be advanced forward into the primary defect in a V-Y manner. While advancing the flap, secondary tissue movement will be necessary, especially given the bulky nature of the pedicle. This motion of pulling the flap forward also allows the surgeon to visually determine which aspect of the flap requires more mobility. If the surgeon places a finger on the pedicle during movement, the remaining vectors of resistance may be determined and additional undermining may be performed to free up movement in this vector. The narrow tail of the flap is often an area that requires additional undermining to lessen restriction on the advancement of the pedicle. Aggressive undermining of the apex, or the tail, can significantly improve the mobility of the flap.

If the pedicle itself requires undermining, this is done with extreme care. The surgeon should test flap mobility after each step of undermining to minimize over-undermining the pedicle and compromising its vascular supply. Usually, the leading edge of the flap is also undermined, but to a lesser degree than the tail.

The key suture of this flap is placed in the deep dermis at the midpoint of the leading edge and the corresponding point of the defect. Buried vertical mattress or set-back sutures are ideally used.¹⁵ Tip stitches for the apex of the flap are generally not necessary. Basting or quilting sutures may be used to tack down the body of the flap, though care should be taken to avoid ligating the flap's vascular supply. After all dermal sutures are placed, the elevation of the pedicle should be lower than that of the surrounding skin, perhaps by as much as 2 to 3 mm. With wound contraction and healing, the pedicle will elevate relative to the position of the surrounding skin.

Due to the nature of the design with free margins on all sides of the pedicle, this flap is particularly susceptible to the trapdoor phenomenon, producing a protuberant aesthetic appearance (Fig. 25-5). This complication commonly develops early during the postoperative period, and occurs more often on the medial cheek or lip. Undersizing the flap will help to minimize the trapdoor deformity, although this requires secondary motion of the edges surrounding the defect. The surgeon must account for and predict this secondary motion in order to properly execute the flap.



Figure 25-5. Pincushioning, or the trapdoor phenomenon, is classically seen with this design.

The classic locations chosen for repair using the island pedicle flap include the upper lip. Other areas for which this flap can be used include the upper brow/temple, lateral upper lip, medial cheek ([Fig. 25-6](#)), upper nasal dorsum, and alar groove. Some of these locations may require the use of a modified flap design.

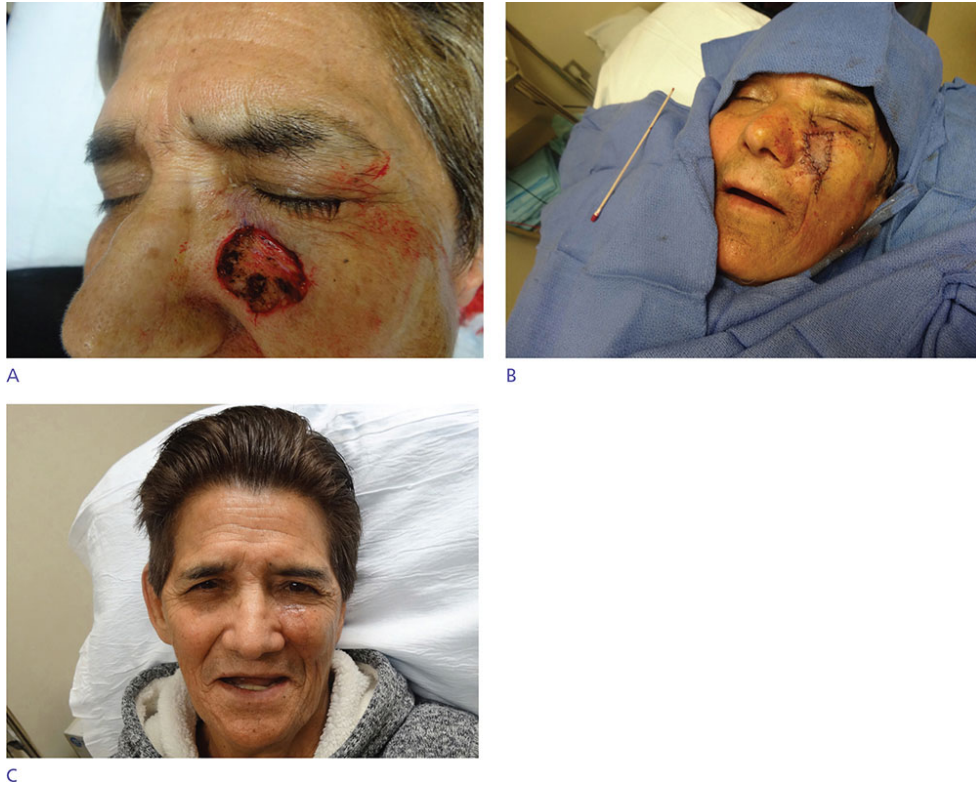


Figure 25-6. This flap may be used beyond the lip and nose, and cheek defects can be reliably reconstructed as well.

FLAP MODIFICATIONS

The island pedicle flap is an excellent reconstructive option that allows for consistently reproducible results. Several design modifications have been introduced to accommodate defects in certain locations or other limitations to using the traditional design of this flap. While the central pedicle provides an excellent vascular supply, the bulkiness of this pedicle can sometimes impede flap mobility. Thus a modification using a laterally based pedicle may improve flap movement while also allowing for adequate perfusion. Dual island pedicle flaps can also be employed, with pedicles of differing sizes.

Unilateral island pedicle or single lateral island pedicle flap

This variation of the traditional island pedicle flap can be beneficial for nasal tip and alar defects. Unlike the conventional design, which maintains a central subcutaneous tissue pedicle, only one lateral edge remains attached while the rest of the pedicle is detached from the subcutaneous tissue. This laterally based pedicle can be comprised of subcutaneous fat or a muscular sling. This modification allows for even greater flap mobility, as the tissue can be more easily advanced or rotated into the defect. When used for defects on the distal nose a lateral pedicle based on the nasalis musculature may be employed, which allows for more predictable perfusion. In locations where nasalis muscle cannot be incorporated, a wider pedicle of laterally based subcutaneous tissue can be recruited.²²

Dual (“bilateral,” “double,” or “bi-pedicled”) island pedicle flaps

Dual island pedicle flaps are used in cases where a single island pedicle cannot be adequately mobilized to reach the distal edge of the defect. This repair can also be used for defects consisting of different tissue types, such as those involving both the upper cutaneous lip and mucosal lip.²³ Dual island pedicle flaps may advance from opposite sides, or in opposite directions (horizontal and vertical).

In one variation, Huilgol et al. conducted a review of 10 patients with defects involving both the upper cutaneous lip and mucosal lip.²³ Using cutaneous upper lip skin and mucosal skin, two island pedicle flaps were designed to fill their respective defects. Once the pedicles were in position, the advancing edges were trimmed to simulate the shape of the vermillion/upper lip boundary. Cosmetic results were excellent. This variation may also be used on the scalp.

Shark island pedicle

The shark island pedicle is a useful modification for combined defects that span the ala and perialar cheek. Its advantage is that it provides a single-stage option that preserves the complex contour of the concave cheek–nose junction. While designed in similar fashion to the traditional island pedicle flap, its descriptive name is due to its leading edge having a similar

appearance to the mouth and snout of a shark. The superior arm of the flap rotates 90 degrees to repair the alar aspect of the defect while the remainder of the advancing pedicle repairs the cheek up to the nasofacial sulcus.

Tunneled island pedicle flap

This modification can be used when the defect and flap pedicle are not immediately adjacent to each other. It allows for preservation of normal tissue in between the flap and the defect. The flap “tunnels” underneath this portion of normal skin to fill the defect.²⁴⁻²⁶

In one example, Wang et al. used the tunneled island pedicle flap to reconstruct an earlobe with preauricular skin, while preserving the normal section of tissue at the medial edge of the earlobe. This tissue separated the defect from the flap. A “tunnel” was created underneath this medial edge, allowing for the pedicle to pass through it to reach the defect. This allowed for a good match of the fibrofatty tissue of the earlobe, thus restoring the normal contour and texture of this tissue location.²⁶

The advantage of this flap modification is that it allows for defects to be repaired in a single stage and preservation of normal tissue. The disadvantage of this flap modification is that it increases the risk of trapdoor phenomenon and may add bulkiness to the intervening normal skin.

Transposition island pedicle flap

This modification of the island pedicle flap, in which the pedicle is transposed at a 30- to 120-degree angle, can be useful in repairs of the medial canthus or lateral nasal ala.^{27,28} For defects of the medial canthus, the glabellar tissue reservoir is used to create the island, which is transposed into the defect. Closing the secondary defect helps with accurate positioning of the pedicle. For the nasal ala, the transposition island pedicle flap can use the reservoir of tissue in the nasolabial fold to create the pedicle used for the defect.

This flap has several advantages, including the ability to avoid the standard pivot-related restraint of transposition flaps, the ability to have the secondary defect not immediately adjacent to the primary defect, the option of using a single-stage flap instead of a two-stage flap, and a superior

vascular supply compared to other transposition flaps. The bulkiness of the flap can also be used to the surgeon's advantage for deep defects in the nasal sidewall or nasal root, or for the recreation of the ala. However, the bulkiness of the flap can also pose as a disadvantage, as it can predispose to trapdooring, result in nasal fullness or protrusion which restricts airflow, and the possibility that stretch and trauma to the pedicle during transposition may cause tip necrosis.

Multistaged island pedicle flap

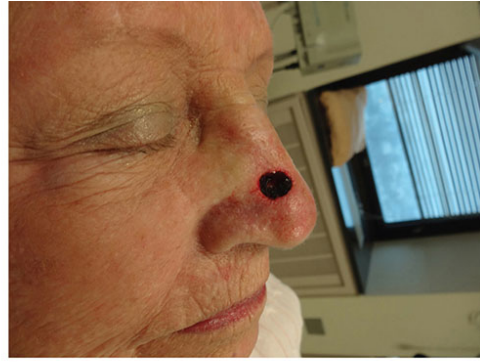
The two-stage island pedicle flap, described as the cheek island pedicle flap, is a useful alternative to the paramedian forehead flap for substantial defects of the lower nose.²⁹ Here, an island of tissue is recruited from the nasolabial fold, and undermined. The pedicle is ideally left at the superior pole of the flap, and the flap is rotated over intervening normal skin to cover the defect. The secondary defect is closed primarily, and flap take-down occurs at approximately week 3 (Table 25-2).

Table 25-2. Pearls in Island Pedicle Flap Design

For the nose, chose small- or medium-sized defects (Figs. 25-7 and 25-8)
Undersize the pedicle
Evaluate mobility of pedicle during movement by palpating the flap while advancing it forward into the defect
When undermining the pedicle, test mobility after each incision to lessen the likelihood of compromising the underlying vascular support
Ensure that the pedicle is recessed in relation to surrounding skin after deep sutures are placed to lessen the risk of trapdoor phenomenon



A



B



C

Figure 25-7. The ideal nasal defect is fairly small.



A



B



C

Figure 25-8. While larger defects may be closed with this technique as well, they run an increased risk of pincushioning, though this may be a valid tradeoff if the suture lines are hidden in cosmetic subunit boundaries.

CONCLUSIONS

The V-Y island pedicle flap, also known as a V-Y advancement flap, is a useful flap that benefits from a robust vascular supply. This random pattern flap can be used in a variety of locations, either as a classic or modified island pedicle flap. The excellent vascular supply and ability to use adjacent or nearby skin to repair the defect allow for predictably excellent cosmetic results, with good color and texture match. Its main disadvantage is the risk of the trapdoor phenomenon, which may be mitigated by precise layered suturing techniques, basting sutures, and undersizing the flap.

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CHAPTER 26 Interpolation Flaps

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SUMMARY

- Interpolation flaps are very effective for large or deep defects, as their robust vascular supply allows closure of distant defects.
- Most interpolation flaps require at least two stages, and the degree of local care and functional and cosmetic compromise between stages means that appropriate patient selection is of vital importance.
- The paramedian forehead flap is the most frequently used interpolation flap in dermatologic surgery, though cheek- to-nose, paranasal, postauricular, lip, and eyelid interpolation flaps are used as well.

Beginner Tips



- The surgeon should precisely design a template that accounts for the three-dimensional shape and contour of the nose.
- Doppler localization of the underlying axial vessel may not be needed.
- It is best to match the thickness and contour as much as possible during the initial inset, though a delicate balance must be maintained as aggressive thinning in the first stage may increase the risk of ischemia.

Expert Tips



- The Abbé flap may result in difficulty with eating or speaking prior to flap division.
- This flap may also appear markedly edematous for up to a year postoperatively, and no revisions should be attempted prior to 6 months to allow this swelling to resolve. Sensory and motor functions are affected during the procedure and it may require a year or more to regain complete neuromuscular function.
- The three-stage paramedian forehead flap may provide a superior cosmetic outcome, though an additional surgical procedure is required.

Don't Forget!



- An oversized flap, or a flap that has not been appropriately thinned, may require a revision with another surgery, intralesional steroids, dermabrasion, or laser.
- Necrosis may be seen more often with the cheek-to-nose flap compared to other interpolation flaps due to its less robust blood supply.

Pitfalls and Cautions



- All patients should be counseled that additional revisions such as dermabrasion or contouring may be required at a later date.
- For the Abbé flap, patients should be appropriately counseled regarding the anticipated difficulty with eating and speaking prior to pedicle division.
- Lymphedema lasting many months is common after eyelid interpolation flaps.

Patient Education Points



- From the patient's perspective, staged interpolation flaps are among the most challenging closures in dermatologic surgery, as they must care for and endure an unsightly pedicle for several weeks postoperatively.
- Paresthesias secondary to transection of the supratrochlear nerve can be permanent, and patients should be counseled about this prior to surgery.

Billing Pearls



- Interpolation flaps on the nose, eyelids, and lips are coded with 15576 at the time of pedicle formation and 15630 at the time of takedown.
- Like all flap codes, there is a 90-day global period associated with these codes.

CHAPTER 26 Interpolation Flaps

INTRODUCTION

A large, complex facial defect may create permanent disfigurement and significant psychological morbidity. While cosmetic expectations differ among patients, all desire to retain a normal-appearing face. Surgeons have many reconstructive options, and their selection is based on the size, location, and depth of the defect.

A properly executed local flap is one of the most reliable options for restoring cosmesis and function. When local random pattern flaps are unable to repair a defect, the surgeon may consider using an interpolation flap, a highly effective technique for large or deep defects. They can be supplied by a named artery (axial pattern flap) or by a rich vascular plexus (random pattern flap), and their robust blood supply allows them to repair distant defects. Interpolation flaps generally require two or more stages for completion, though single-staged variants have been described.¹ During the first stage, the surgeon transfers the flap into the defect, leaving the vascular supply attached to its pedicle. During the second stage of the procedure, approximately 3 to 4 weeks later, the pedicle is divided, and the flap is inset. Given the complexity of these repairs, and the need to care for a cosmetically unsightly pedicle until takedown occurs, appropriate patient selection is essential.

An extensive preoperative conversation should take place between the surgeon and the patient when an interpolation flap is anticipated. The surgeon should assess what is required to repair the defect, the limitations of the patient's anatomy, and whether this type of flap is reasonable for this particular patient. The patient should have a driver present and have someone at home to assist with wound care. Photos of prior repairs can be shown to the patient and caregiver to help them visualize and comprehend the

procedure. Some patients may not wish to undergo a multistage procedure, and the surgeon must always balance the complexity of the procedure (and attendant postoperative care) with the desire for a perfect reconstruction. All available alternatives should be discussed with a patient, even if they provide inferior cosmetic and functional outcomes, to allow the patient to make an informed decision. Certain social situations may preclude the use of interpolation flaps, and other reconstructive options should be considered for patients who live alone or for those who suffer from decreased mental status and may manipulate the repair prior to the second stage.

PARAMEDIAN FOREHEAD FLAP

The paramedian forehead flap (PFF) is a resilient, highly vascularized flap that is best used to repair large, complex defects on the nose. The sebaceous skin on the forehead provides a suitable color and texture match for this area, and the vascularity of the pedicle allows the flap to reach considerable distances. It is traditionally based on the supratrochlear artery, which lies approximately 1.5 to 2 cm from the midline of the glabella. The supratrochlear artery exits the supratrochlear foramen, crosses the corrugator supercilii, and pierces the frontalis muscle just above the level of the orbital rim. It continues to ascend vertically in the subcutaneous tissue.

Flap design

When designing any flap, it is important to consider function, free margins, and form. The PFF cannot simply be placed on the distal nose without proper structural support to prevent collapse of the nasal valve. Cartilage grafts provide structural support, prevent alar retraction, and also help to restore the normal form and contour of the nose.^{2,3} The grafts are often harvested from the conchal bowl or antihelix for convenience, though nasal septum and costal sources can also be considered. If the nasal lining is not intact, mucosal flaps, hinge flaps, bipedicle septal flaps, or inverted full-thickness skin grafts can be used.⁴⁻⁷ A three-stage fold-over PFF is an excellent option for repair (Fig. 26-1A,B).



Figure 26-1. (A,B) Recreating the intranasal lining using a three-stage fold-over paramedian forehead flap.

For defects involving >50% of a cosmetic subunit, enlarging the operative wound to encompass the entire subunit may provide a superior aesthetic outcome. A template of the defect is made using gauze, Telfa, steri-strips, or foil from a suture packet prior to excision of the remaining subunit (Fig. 26-2). The template is then rotated 180 degrees onto the forehead (Fig. 26-3). The contralateral forehead is often chosen for the flap as this rotates with less torsion. If the defect is midline, either side of the forehead can be used, and laterality is decided based on the quality of the skin and the lack of any other local suspicious lesions. The distance from the anterior hairline to the superior orbital rim is measured to determine the length of the flap (Fig. 26-4A,B). If the reach is not adequate, the flap may extend onto the scalp or below the superior orbital rim. A paramidline flap design located 1.2 cm lateral to the midline of the glabella may be beneficial when longer flaps are needed, as extending the pedicle inferiorly does not affect the brow.⁸ Extension onto the scalp will transfer terminal hairs to the nose, though this should not prevent the use of this repair, as creating a normal-appearing nose takes precedence. The flap can be thinned distally to remove hair follicles, or the patient can shave, epilate, or undergo laser hair removal or electrolysis postoperatively.



Figure 26-2. A three-dimensional template is created using steri-strips.



Figure 26-3. The template is inverted onto the forehead. The pedicle is marked 6 mm to each side of the most prominent corrugator crease.



A



B

Figure 26-4 (A,B) The distance from the base of the pedicle to the top of the template is measured with gauze. The gauze is then rotated toward the nose to confirm flap reach.

The vascular supply of the pedicle is based on the supratrochlear artery, which may be determined based upon anatomical landmarks or using a handheld Doppler ultrasound. No difference in flap survival or complications was seen when comparing these two techniques.⁸ The most prominent glabellar frown line and 6 mm of lateral skin reliably corresponds

to the location of this artery, and can be used in lieu of Doppler localization.⁹ The width of the pedicle is rarely greater than 1.5 cm, as wider pedicles may limit the flap's mobility and impair blood supply due to greater torsion and compression of the artery.

Flap elevation

If the defect extends to other cosmetic subunits, such as the cheek, it is best to repair these separately in order to maintain the natural cosmetic boundaries of the face. After extranasal portions of the defect have been repaired, the forehead is prepped in a sterile fashion and anesthetized. An incision is made on the superior forehead in a subcutaneous plane. The templated portion of the flap is elevated more superficially to minimize the need for pre-inset debulking. Once this distal portion has been elevated, the level of dissection should transition to a deeper plane, just above the periosteum. Including frontalis muscle (and possibly galea) in the pedicle of the flap minimizes the risk of transecting the supratrochlear artery and ensures an adequate vascular supply.¹⁰ Once elevated, the flap should drape over the defect without tension (Fig. 26-5).



Figure 26-5 The flap drapes over the defect with no tension.

Flap inset

The edges of the defect are squared off to receive the flap, and the flap is thinned to match the defect. Flap thinning and contouring can be delayed if adequate vascularity is a concern, such as in a smoker. Cutaneous or dermal sutures are used to secure the leading edge of the flap to the defect.

Donor site closure

The forehead should be undermined in a subgaleal plane and meticulously closed to prevent an inverted scar. An excessively tight closure should be avoided, and second intention healing may be required if complete closure is not possible ([Fig. 26-6](#)).



Figure 26-6. The forehead defect cannot be completely closed primarily and is left to heal by second intention.

Postoperative instructions

Pinpoint electrocoagulation may be used along the pedicle to provide hemostasis, though the area often continues to ooze postoperatively as the epinephrine effect wears off. Wrapping the pedicle in oxidized regenerated cellulose gauze (Surgicel, Ethicon, Inc., Somerville, NJ) may help reduce

bleeding.¹¹ A bulky pressure dressing is placed which may obstruct peripheral vision and prevent the patient from wearing glasses (Fig. 26-7). Having a driver is therefore necessary. The patient returns in 1 week for a dressing change.



Figure 26-7. Pressure dressing in place following paramedian forehead flap.

Second stage

Three weeks later, the patient returns for pedicle division and distal flap thinning. The pedicle is first cut at the base. The entire stump can be excised and repaired with a linear closure, or inset with a V-Y repair. Incisions are recreated along the original wound, and the flap is thinned and sutured into place (Fig. 26-8A,B).



Figure 26-8. (A) Patient returns at 1 month for flap takedown. (B) Completion of the second stage.

Technique pearls

The surgeon should precisely design a template that accounts for the three-dimensional shape and contour of the nose (Fig. 9A,B). It is best to match the thickness and contour as much as possible during the initial inset, though a delicate balance must be maintained as aggressive thinning in the first stage may increase the risk of ischemia. An oversized flap, or a flap that has not been appropriately thinned, may require a revision with another surgery, intralesional steroids, dermabrasion, or laser. This is often addressed 4 to 6 months from flap takedown.

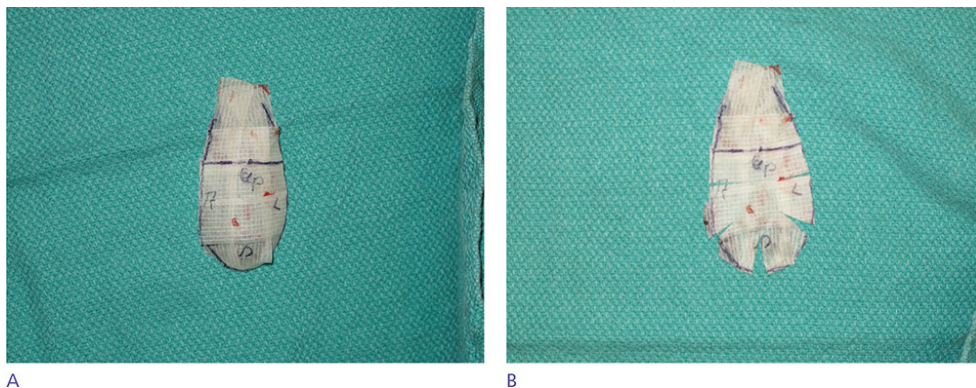
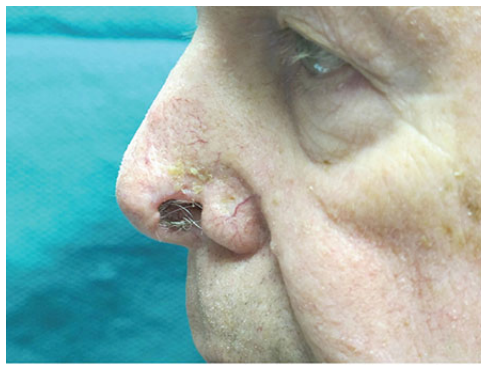


Figure 26-9. (A,B) The three-dimensional template is carefully removed to keep its shape. Relaxing incisions are made to flatten the template prior to transferring onto the forehead.

Surgeons should also devote time to repairing the secondary defect on the forehead to prevent a noticeable, inverted scar. If tension is too great, the area should be left to heal by secondary intention.

Paresthesias secondary to transection of the supratrochlear nerve can be permanent and patients should be counseled about this prior to surgery.

Necrosis is rare given the reliable blood supply to this flap, though it may occur in the setting of extreme tension or if the patient is a heavy smoker. Superficial slough can be removed at the time of division and left to heal by secondary intention. In the catastrophic event of complete flap failure, observation is recommended. The pedicle will autoamputate and revisions can be performed at a later date if needed. In general, this flap approach is reliable and leads to excellent aesthetic and functional outcomes (Fig. 10A–M).



A



B



C



D



E



F



G



H

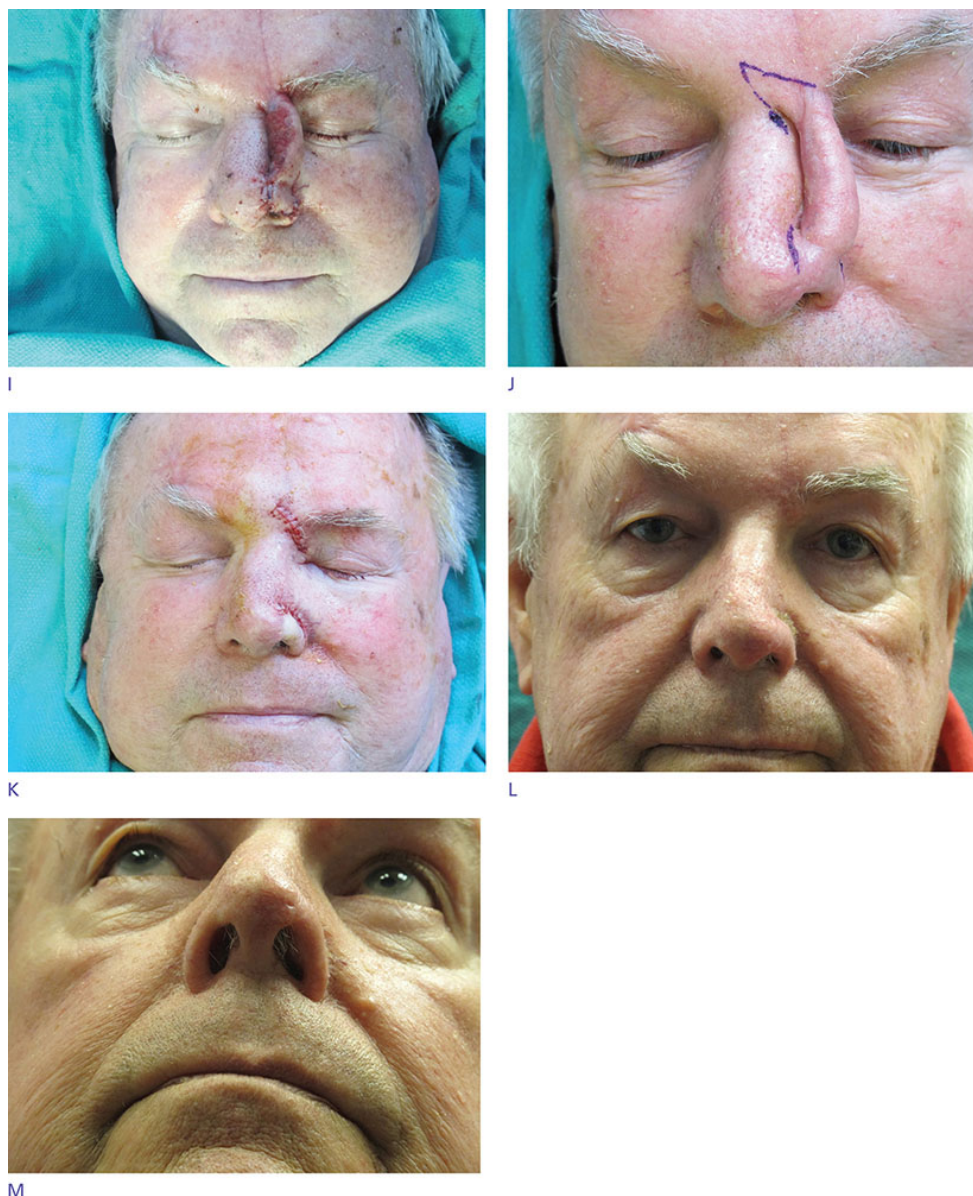


Figure 26-10. (A) Full-thickness defect on the left nasal ala following Mohs surgery. (B) Template made from contralateral ala. (C) Template inverted onto forehead. (D) Fold-over flap used to recreate nasal lining. Pedicle wrapped with Surgicel and flap sewn into place. (F) Return for the second stage 3 weeks later with planned division at the alar rim. (G) Pedicle divided at the alar rim and internal lining visible. (H) Pedicle and internal lining are thinned appropriately. (I) Pedicle is resutured. (J) Return for the final stage 3 weeks later (6 weeks from stage 1). (K) Division of pedicle performed. (L) Postoperative appearance at 1 month (frontal view). (M) Postoperative appearance at 1 month (inferior view).

CHEEK-TO-NOSE INTERPOLATION FLAP

The cheek-to-nose interpolation flap (CIF), or melolabial interpolation flap, is a random pattern flap based on tributaries from the angular artery. It is best used for deep defects isolated to the nasal ala.^{12–15} The flap derives from the sebaceous skin of the medial cheek, which provides a good color and texture match for this area, and the donor site scar is camouflaged in the melolabial fold. One disadvantage of this flap is the potential transfer of terminal beard hairs in men. This can be addressed through thinning of the flap or postoperative hair removal as described above for the PFF.

Flap design

Loss of muscle in the nasal ala reduces structural support, and a cartilage graft is often required to prevent nasal valve collapse, maintain airway patency, prevent contraction of the alar rim, and provide bulk to restore the natural alar convexity.² Pushing against the alar rim to detect resistance and watching for alar collapse as the patient inspires can be helpful to gauge the need for additional support.² If vestibular lining is required, the flap can be designed to fold over onto itself, though a PFF may be better suited for these larger, full-thickness defects. A template is made of the defect, often using the contralateral ala as a reference. The template is then rotated onto the cheek so that the superior portion lies along the melolabial fold and the inferior portion lies laterally. Burow's triangles are drawn above and below the template to create an ellipse. Flap reach is confirmed with a suture or stretched gauze, ensuring that neither is stretched too tightly. Always overestimate flap length.

Flap elevation

The flap is incised and elevated at the level of the subcutaneous fat on its distal edge. Some surgeons may transition to a deeper plane when approaching the proximal pedicle to include muscle fibers from the levator labii superioris alaeque nasi, which increases the vascular supply. The pedicle can retain attachments to the cheek at the superior portion of the most proximal Burow's triangle (peninsula), or it can be freely mobilized on its subcutaneous pedicle. The former increases the vascular supply, while the latter reduces torsion and allows for easier division and inset. The flap is

lifted and rotated counterclockwise for a right-sided defect or clockwise for a left-sided defect. It should cover the defect with no tension.

Flap inset

The distal portion of the flap is thinned as needed to match the defect. The edges of the defect are squared off and prepared to receive the flap. Undermining the nasal skin may help prevent pincushioning. The flap is secured with cutaneous and dermal sutures. The alar crease should be left to heal by the second intent, tacked down, or sutured with inverting sutures to maintain the concavity.¹⁶

Postoperative instructions

Dressings are less cumbersome than for the PFF, as the patient may drive and wear glasses. The exposed pedicle is gently cauterized and wrapped with Surgicel or Xeroform gauze. A pressure dressing is left in place for 24 to 48 hours. The patient returns 1 week later for dressing change.

Second stage

The pedicle is divided 3 weeks later, starting with the base. If the pedicle maintained attachments to the cheek, the entire base of the pedicle must be excised with an ellipse and repaired with a layered closure. If the base was unattached, it may be inset back into the cheek with a V-shaped incision or similarly removed with an elliptical excision. The flap can also be additionally thinned at this time if needed.

Technique pearls

Flattening of the melolabial fold occurs as a result of this flap, though this is usually mild and not bothersome to the patient. If needed, an elliptical excision of the contralateral melolabial fold can recreate symmetry.

Necrosis may be seen more often with the CIF compared to other interpolation flaps due to its less robust blood supply. When this occurs, it most often involves the distal edge of the flap which can be left to heal by

secondary intention. These flaps also have a tendency to pincushion, which may be of benefit to restore the convexity of the ala. If it is problematic, intralesional triamcinolone can be used starting approximately 1 month after takedown. All patients should be counseled that additional revisions such as dermabrasion or contouring may be required at a later date (Fig. 11A–G).



A



B



C



D



Figure 26-11. (A) Basal cell carcinoma on the left nasal ala. (B) Defect following Mohs micrographic surgery. (C) Flap sewn into place and pedicle wrapped with Surgicel and Xeroform gauze. (D) Flap survival at 3 weeks. (E) Pedicle division and inset. (F) Postoperative appearance at 6 months (oblique view). (G) Postoperative appearance at 6 months (frontal view).

PARANASAL INTERPOLATION FLAP

The paranasal interpolation flap (PIF), a variation of the CIF, is a random pattern flap derived from the lateral nasal sidewall and nasofacial sulcus.¹⁷ Since this is a nonhair-bearing area, this flap can prevent the transfer of facial hair to the nasal ala as may occur with the traditional CIF in men. Another advantage of this location is that the pedicle has a smaller axis of rotation, which causes less torsional strain and requires a shorter flap. The donor site location also prevents the flattening and asymmetry of the melolabial fold observed with the traditional CIF. This flap is best used for small- to medium-sized defects isolated on the nasal ala. Patients with excessive lower eyelid laxity are not good candidates for this repair due to the risk of ectropion.

Flap design

A template of the defect is created using the contralateral ala as a reference. The width of the flap should equal the vertical height of the defect, and an ellipse is created surrounding the template. If needed, a cartilage graft can be harvested prior to flap elevation and placed as described previously.

Flap Elevation

An incision is made just lateral to the ala and continued superiorly into the melolabial fold and nasofacial sulcus. This represents the medial portion of the flap and another incision is made laterally to parallel this. The flap is elevated just below the dermis. Transitioning to a deeper plane occurs as the base of the pedicle is approached to preserve the vascular plexus.

Flap inset

The flap is rotated into place under no tension, secured with buried and cutaneous sutures, and trimmed as needed. The donor site on the cheek is undermined and closed primarily. Lower eyelid tone should be carefully assessed during this closure to avoid ectropion.

Second stage

The patient returns 3 weeks later for division and inset. The pedicle is divided lateral to the defect and the flap is appropriately thinned. The edges of the defect are freshened, and the flap is sewn in place. The base of the pedicle is excised with an elliptical excision, undermined, and closed primarily.

Technique pearls

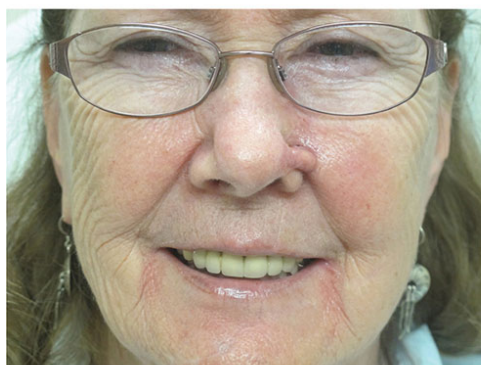
Revisions such as laser, dermabrasion, intralesional Kenalog, or additional surgeries may be needed at a later date as previously described (Fig. 12A–G).



A



B



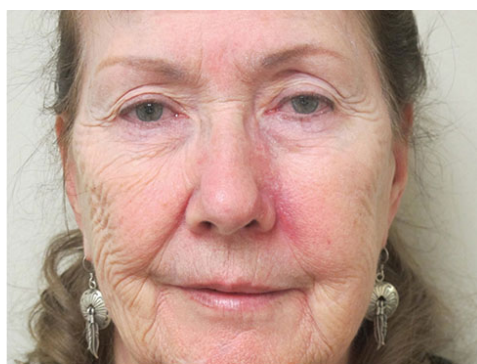
C



D



E



F



G

Figure 26-12. (A) Defect on left nasal ala following Mohs surgery. Template for paranasal flap drawn along the nasofacial sulcus. (B) Pedicle in place and donor site closed. (C) Patient returns for takedown

at 4 weeks. (D) Division and inset completed. (E) Postoperative appearance at 1 month (oblique view). (F) Postoperative appearance at 1 month (frontal view). (G) Postoperative appearance at 6 months (oblique view).

POSTAURICULAR INTERPOLATION FLAP

Wounds that involve the helical rim can be challenging to repair without altering the shape of the ear. When perichondrium is intact, a full-thickness skin graft may effectively restore cosmesis. This is not suitable, however, if only cartilage remains in the wound bed. Though cartilage may eventually heal by secondary intention, there is an increased risk of infection, inflammation, and destructive chondritis. Random patterned, pedicle flaps from the posterior ear provide a reliable alternative for large defects involving the helix and anterior ear.^{12,14,18} This repair produces a highly aesthetic result that maintains ear size and contour. Additionally, the donor site is hidden from view and heals very well.

Flap design

The location for the flap is selected on the postauricular skin. A template of the defect is made and transferred to the donor site. The ear should be folded back to the mastoid process and the vertical height of the defect measured to ensure the flap is not undersized. Depending on the size of the wound, the pedicle can involve only the mastoid process or may extend to the postauricular sulcus and posterior ear. A preauricular donor site or other reconstructive options may be considered when patients have a hairline abutting the postauricular sulcus, to prevent the transfer of terminal hairs onto the ear.¹⁴

Flap elevation and mobilization

An incision is made along the anterior border and both sides of the flap. The skin is elevated above fascia at the mastoid process or above perichondrium on the posterior ear and postauricular sulcus. The distal portion of the flap may be thinned, but a thin layer of adipose should remain on the flap to ensure viability. Meticulous hemostasis is important because visualization

will be difficult after the flap is placed. The flap is then draped over the defect. Both the primary and secondary defects can be undermined slightly to increase mobility.

Flap inset

The flap is sutured into place with cutaneous sutures starting at the anterior surface of the ear and extending to the helical rim. Basting sutures can be used to recreate the natural contour of the helical rim. This can be accomplished during the first or second stage, but may be easier during the first stage since wound contraction can cause flattening of the pedicle.¹⁸ If a full-thickness defect is present, the flap can be folded onto itself to recreate the helical rim. A cartilage graft is rarely needed in this instance unless a large portion of the cartilage is missing. This flap is broad-based and placed without torsion, so it can tolerate some tension without compromising vascularity; minimal to no tension should exist if properly sized.

Postoperative instructions

Patients often tolerate this procedure very well, as the pedicle is camouflaged behind the ear and they can wear glasses and hearing aids after the initial pressure dressing is removed in 24 to 48 hours. Continued drainage from the pedicle is a nuisance for many patients, and this should be discussed preoperatively. Packing or a penrose drain may be inserted in the postauricular tunnel to mitigate this concern. The dressing is changed 1 week later.

Second stage

The patient returns 3 weeks later for division of the pedicle. The stump can be removed entirely, leaving the secondary defect on the mastoid or posterior ear to heal by secondary intention. Alternatively, the wound edges can be freshened and the pedicle returned to its original position. The remaining flap is thinned as needed and sutured into place. Vertical mattress sutures can be helpful where the flap crosses the helical rim to prevent notching.

Technique pearls

Like all interpolation flaps, it is important to accurately measure the distance the flap needs to travel to reach the defect. In the case of the postauricular interpolation flap, the defect can extend onto the posterior ear if additional reach is needed.

Blunting of the helical rim can occur with this repair. While this does not bother some patients, folding the flap over and using basting sutures can help recreate the helical rim. Blunting of the scaphoid fossa, caused by bridging between the helical rim and antihelix, can also be prevented by the use of basting sutures.

Eversion is most important on the helical rim to prevent notching, and vertical mattress sutures can be helpful in this location (Fig. 13A–G).



A



B



C



D



Figure 26-13. (A) Squamous cell carcinoma on the left helix. (B) Full-thickness defect following Mohs surgery. (C) Template for postauricular interpolation flap drawn. (D) Flap sewn into place. (E) Patient returns for takedown 4 weeks later. (F) Division and inset completed. Basting sutures placed to restore contour of helical rim. (G) Postoperative appearance at 6 months.

ABBÉ FLAP

The Abbé flap (or lip-switch flap) is an axial patterned flap based on either the superior or inferior labial artery.^{19,20} It is used to repair large, full-thickness defects involving 1/3 to 1/2 of the upper or lower lip, and involves the transfer of skin, muscle, and mucosa. It has also been used in cleft lip repair.²⁰ This repair should not be used for defects involving the oral commissure. Both the inferior and superior labial arteries originate from the facial artery near the oral commissure, and anastomose with the opposite side to encircle the lip. They are typically found between the oral mucosa and orbicularis oris muscle, though they can be found within the orbicularis muscle in a small number of cases. While the labial arteries are never located superficial to the muscle, their depth varies, and they are found

closer to the free margin of the lip at the midline relative to the oral commissure.

Flap design

The surgeon should mark the vermillion border prior to infiltration of local anesthetic, as this margin often becomes distorted. Infraorbital or mental nerve blocks may be used to minimize some of this distortion. The flap is designed in a midline or paramedian location with a width that is approximately 50% the width of the defect. This helps to maintain the proportions of both lips, since closure of both the primary and secondary defects causes a similar reduction in width. The vertical height of the flap should be equal to the height of the defect. For extensive defects, an extended Abbe flap that includes skin beyond the mental crease has been described.^{21,22} Defects of the upper lip may be extended to replace the entire subunit and hide suture lines in the nasal sill or melolabial crease. A template is made and transferred to the desired location on the opposite lip. A medially or laterally based pedicle can be considered, but the side ipsilateral to the defect is often chosen to allow for a larger oral aperture postoperatively.

Flap elevation

Scoring incisions can be made at the vermillion border on both the flap and recipient defect to allow for precise re-approximation if skin markings become blurred. A full-thickness incision is made on the side opposite the pedicle. The labial artery is identified and ligated. The surgeon then moves to the pedicle side of the flap and transitions to blunt dissection at the orbicularis muscle to prevent transection of the labial artery. The pedicle should be approximately 1 cm in size to preserve venous outflow, which limits congestion and edema, as a wider or thicker pedicle can compress both the arterial supply and venous return. Hemostasis is achieved, and the donor site is closed in a layered fashion starting with oral mucosa. When suturing mucosa, the suture knots should face the oral cavity. Of note, a small opening should remain in the donor site at the origin of the pedicle to facilitate its rotation. The flap is rotated 180 degrees toward the defect.

Flap inset

The flap is inset and closed in a layered fashion identical to the donor site closure. The vermillion border should be carefully reapproximated. In addition, it is important to accurately align the orbicularis oris muscle to restore function.

Postoperative instructions

The Abbe flap serves as a connection between the upper and lower lips and prevents complete opening of the mouth. A liquid or soft diet is needed until pedicle division. Because narcotics can cause nausea and vomiting, antiemetics should be prescribed, or nonnarcotic analgesics should be considered. Many surgeons may also administer intraoperative or postoperative antibiotics. A bulky dressing is not needed for this repair and standard wound care with petrolatum ointment is recommended.

Second stage

The patient returns 3 weeks later and the pedicle is divided with a V-shaped incision. The resulting V-shaped defect on the recipient lip is closed primarily. The pedicle stump may be returned to the donor lip or excised and repaired with a linear closure. Pain is typically less after this stage than the first, and the patient may begin eating after surgery.

Technique pearls

Patients should be appropriately counseled regarding the anticipated difficulty with eating and speaking prior to pedicle division. Many patients are concerned about the edematous appearance of the flap, and they should be reassured that edema is normal for 4 to 6 months. No revisions should be attempted prior to 6 months to allow this swelling to resolve. Sensory and motor functions are affected during the procedure and it may require a year or more to regain complete neuromuscular function. Permanent dysfunction is possible, though rare, and patients should be appropriately counseled.

Misalignment of the vermilion is noticeable, and is more easily prevented than revised.

CUTLER–BEARD FLAP

The Cutler–Beard flap is a cutaneoconjunctival flap of the lower eyelid that is used to repair large, full-thickness defects of the upper eyelid. The donor site on the lower eyelid provides a perfect color and texture match, and the skin in this area is loose and able to stretch easily.

Flap design

The width of the defect is measured and a template is created. The template is transferred to the lower eyelid below the tarsal plate, and a rectangular flap is created.

Flap elevation and inset

A horizontal incision is made approximately 2 to 3 mm beneath the inferior tarsal plate and extended full thickness through the lower lid. Westcott scissors are useful to reach the desired depth on this thin skin. The flap is completed by two parallel, vertical incisions and transferred under the inferior tarsal plate. The lower lid palpebral conjunctiva is carefully dissected off the orbicularis muscle and attached to the levator aponeurosis and edge of the upper lid conjunctiva. The surgeon may consider using auricular cartilage or a free tarsal graft on the top of the conjunctiva to add support.²³ The skin and muscle of the lower eyelid flap are then advanced superiorly and sewn onto the upper lid in a layered fashion. The lower lid defect remains open.

Postoperative instructions

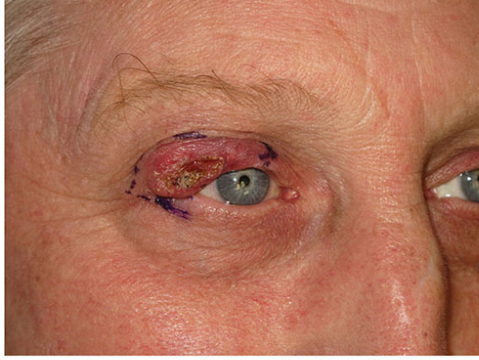
A dressing is applied for 48 hours. The patient's eyelid is sewn shut until division several weeks later, which can be very difficult for the patient, particularly if vision in the contralateral eye is poor.

Second stage

The patient returns 4 to 8 weeks later and the pedicle is divided. The pedicle recoils inferiorly and is sutured to the lower lid margin. The upper eyelid conjunctiva is advanced to the lid margin.

Therapeutic pearls

Lymphedema is a common problem in this area, and persists for many months. Ectropion can result from lower eyelid laxity, and a lid-tightening procedure may be warranted. Entropion of the upper eyelid can occur, allowing hair and skin to touch and irritate the cornea. Ensuring the new anterior lamella is firmly attached to the cartilage or free tarsal graft can help prevent this. Given the morbidity and potential complications of this repair, it should be reserved for large defects when other reconstructive options have been deemed unsuitable. A modified Cutler–Beard flap with earlier pedicle division has been described.²⁴ In this procedure, a free tarsal graft is harvested from the contralateral upper eyelid and sutured to the posterior lamella and levator aponeurosis. A skin-only flap is created on the lower lid, and is elevated and sutured in a manner similar to the traditional Cutler–Beard flap. The pedicle is divided at 2 weeks and returned to the lower eyelid. The authors describing this technique found no cases of necrosis or entropion, though one patient had ectropion (Fig. 14A–J).²⁴



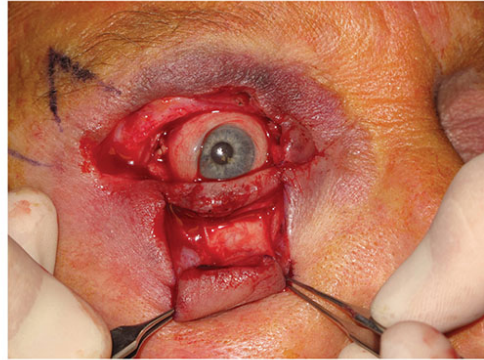
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B



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Figure 26-14. (A) Tumor on right upper eyelid. (B) Full-thickness upper eyelid defect following Mohs micrographic surgery. (C) Template drawn on lower eyelid. (D) Flap incised and elevated. (E) Flap passed under the tarsal plate. (F) Cartilage graft placed for structural support. (G) Flap sewn in place. (H) Flap survival at follow-up 10 weeks later. (I) Pedicle divided. (J) Postoperative appearance at 1 month.

HUGHES FLAP

The Hughes flap is traditionally used for large, full-thickness defects of the lower eyelid involving >50 % of the lid margin. It is a tarsoconjunctival flap

from the upper eyelid that reconstructs the posterior lamella. The anterior lamella is often repaired with a full-thickness skin graft or advancement flap.

Flap design

The width of the defect is measured to determine the width of tarsus required. If greater than 2 cm is needed, the tarsal graft can be expanded to include conjunctiva at its edges. The upper lid is everted and marked 3 to 4 mm back from the superior lid margin, as this amount of lid margin is required to prevent entropion.^{23,25}

Flap elevation

The tarsus is incised and dissected off the orbicularis muscle with Westcott scissors to its superior edge. Dissection also occurs in a plane between Muller's muscle and the conjunctiva up to the superior fornix to transfer conjunctiva in the flap with the tarsus. Vertical incisions are made at the medial and lateral edges of the tarsus to allow for flap movement.

Flap inset

The newly created flap is brought down to the lower eyelid and attached to the conjunctiva. The anterior lamella can be recreated with a full-thickness skin graft or with an advancement flap from the cheek.

Postoperative instructions

A patch is often placed for 1 week, and the patient's eye is sewn shut until the second stage of the procedure.

Second stage

The pedicle is divided typically 3 to 4 weeks later, with an incision made just above the lower lid margin. A modified Hughes flap with pedicle division at 1 week has been described with no cases of flap necrosis or

failure.²⁵ The pedicle recoils superiorly and the remaining flap is removed at the upper lid tarsal plate.

Therapeutic pearls

Upper lid retraction can occur in 19% to 32% of patients if dissection during flap elevation does not extend into the superior fornix or if Muller's muscle and the levator aponeurosis are transferred into the flap.²⁶ The patient will lack eyelashes on the lower lid, but this flap otherwise provides an acceptable cosmetic and functional outcome. Bipedicle tarsoconjunctival flaps have also been reported, and prevent visual obstruction.²⁷

CONCLUSIONS

Surgeons often face large, complex defects after the removal of a skin cancer. Areas such as the eye, nose, and ear are challenging to repair due to their intricate three-dimensional shape, and one must carefully consider form, function, and free margins when selecting an option for reconstruction. Interpolation flaps are an excellent option for these difficult defects in the right patient, and can reliably and safely be performed in the outpatient setting under local anesthesia.²⁸

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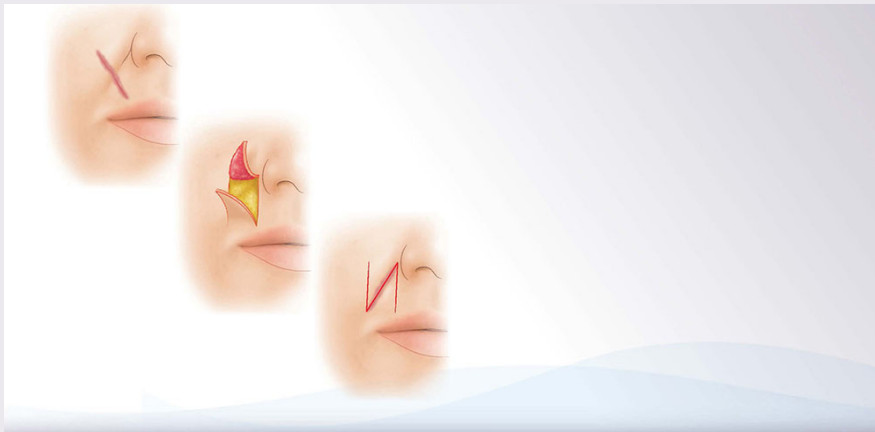
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CHAPTER 27 Z-Plasty

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Daniel B. Eisen



SUMMARY

- The Z-plasty is a powerful technique utilizing the transposition of triangular flaps to relieve tension, to lengthen, and to reorient scars parallel to relaxed skin tension lines.
- A 60-degree Z-plasty is considered optimal when considering skin laxity, size of the flaps needed for viability, risk of vascular compromise, location, and theoretical limitations.
- The Z-plasty may be used on its own for scar revision or repositioning, or as an adjunct to other flap closures to mitigate pivotal restraint.

Beginner Tips



- Z-plasty is useful for the functional improvement of contractures, web revision, or free-margin distortions
- Two equivalent triangular flaps synchronously interchange into the space previously occupied by the other. The result of the position swap is a 90-degree reorientation of the common arm of the Z.

Expert Tips



- Fundamental goals of the Z-plasty procedure include:
 - Realignment of a scar within relaxed skin tension lines (RSTLs), or parallel to them
 - Lengthening of a scar
 - Release of a contracture by scar lengthening
 - Dispersal of a scar for better camouflage

Don't Forget!



- In one study, survey respondents preferred a simpler and less complex linear scar over Z-plasty scars, suggesting that the purported benefit of breaking up long scars into smaller ones needs more study before it can be accepted.
- Although the surgeon has two choices for the placement of these lateral limbs, only one combination will allow for optimal cosmesis or reorientation of lines in the direction of, or parallel to, the RSTL.

Pitfalls and Cautions



- If a scar already lies along RSTL, a Z-plasty may result in reorientation of the central incision perpendicular to the RSTL—a less desirable outcome.
- Scars within 40 degrees of RSTLs may be better managed with simple excision rather than with Z-plasty.
- Necrosis is more common with angles less than 30 degrees and therefore such acute angles should be avoided if possible.

Patient Education Points



- While a Z-plasty does result in a longer scar line, patients may be reassured that the net result is generally a less cosmetically obvious scar.
- Other scar revision procedures may be needed after Z-plasty, and patients should be warned of this eventuality prior to surgical intervention.

Billing Pearls



- Z-plasty is billed using the adjacent tissue transfer (flap) code series, 140XX.
- These codes include a 90-day global period.
- If a Z-plasty is performed as part of a larger flap, only a single flap code should be used.

CHAPTER 27 Z-Plasty

INTRODUCTION

The Z-plasty is a standard technique utilizing the transposition of triangular flaps to relieve tension, lengthen, and reorient scars parallel to relaxed skin tension lines (RSTLs). This technique has been utilized for over a century with only slight modifications, relying on three incisions separated by angles of the surgeon's choosing. Though a variety of different angles can be used, 60 degrees is considered optimal when considering skin laxity, size of the flaps needed for viability, risk of vascular compromise, location, and theoretical limitations.

HISTORICAL PERSPECTIVES

Introduction of the Z-plasty dates back several centuries.¹ In the early 1800s, Fricke and Horner described single transposition flaps, the fundamental basic subunit of the Z-plasty. In his 1837 clinical report, Dr. William Horner illustrated its use for ectropion repair.² Later, Serre and Denonvilliers were invoking its use for facial reconstruction.^{3,4} In 1904, Berger exchanged triangular flaps of equal size and equal angles for axillary web contracture correction, performing the first double transposition Z-plasty 9 years before the term “Z-plasty” was used.⁵ In 1913, McCurdy published a paper entitled, *Z-plastic surgery: plastic operations to elongate cicatricial contractions of the neck, lips and eyelids and across joints*.⁶ Later, variations of the Z-plasty arose to include multiple Z-plasties, proposed by Morestin in 1914, for the treatment of retracting scars of the hand.⁷

Limberg expounded on the mathematical basis of the technique, delineating nuances previously ambiguous to many in his handbook for surgeons published in 1963.⁸ This work explained with two-dimensional models the movement of flaps and the reaction to their action in the adjacent tissue. Defining the geometric principles of the basic Z-plasty technique, he wrote: “Geometrical selection of symmetrical forms of convergent triangular flaps shows decrease in width and growth in length at the ends of the diagonals.”⁸ Its biomechanics was further refined by McGregor, who applied the law of cosines to the inherent foundation of the Z-plasty design which is utilized today.⁹

APPLICATIONS

Few comparative studies exist in the literature for Z-plasty versus other methods of repair. A retrospective review of a Japanese plastic surgery department’s cases of axillary scar contractures over the last 25 years showed that 31 axillary scar contractures were treated with Z-plasty, all of which showed no flap necrosis, though two cases of scar contracture recurrence were reported.¹⁰ Another prospective study of 82 patients undergoing partial selective fasciectomy for Dupuytren’s contractures compared the Z-plasty to two established models, and the incidence of flap necrosis with the Z-plasty was 7%.¹¹ In 2007, Tatlidede et al. studied resistance to tensile loads of various closures with 4–0 silk in murine models and concluded that Z-plasty was superior to linear incisions.¹² The breaking forces of the Z-plasty were roughly two times higher than that of the linear incisions 4 weeks after surgery, which may be explained by differences in contact surface area of the incision lines and decreased tensile forces which act on oblique lines of transposition flaps, as suggested by the authors.¹² Ertas et al. used murine models to study the effective elongation achieved by the Z-plasty or the subcutaneous pedicle rhomboid flap in inguinal skin and found that both techniques were effective in relieving tension over the inguinal areas and in lengthening tension lines, with the Z-plasty producing a greater than 200% gain in length.¹³

A retrospective study by Fader et al. reviewed the University of Michigan Mohs Database from 1998 to 2000 in an effort to identify cases where flap

transposition was used.¹⁴ Their analysis revealed that Z-plasty was used in 12 of 614 patients with cheek defects, all with good to excellent cosmetic and functional outcomes as rated by patient and surgeon.¹⁴ Of those, a double Z-plasty was performed in a subset of four cases. While no infection occurred, minor superficial tip necrosis occurred at one site.

One of the purported benefits of Z-plasty is that it takes a linear scar and breaks it up into smaller segments that, though longer in combined length than the original scar, are less aesthetically noticeable. This dogma was tested in a prospective national survey that assessed the public's aesthetic rating of computer-generated linear facial scars in three different locations in four individuals.¹⁵ Survey respondents significantly preferred the simpler and less complex linear scar over Z-plasty scars, suggesting that the purported benefit of breaking up long scars into smaller ones needs more study before it can be accepted. Thus, while Z-plasty is clearly useful for functional improvements of contractures, web revision, or free-margin distortions, as well as scar reorientation, its utility beyond these applications remains unproven.

The Z-plasty technique

The classic Z-plasty is a surgical method of scar repair which is defined by a Z-shaped incision. The method relies on the transposition of the two triangles created by the angles of the arms of the Z-incision. In other words, two equivalent triangular flaps synchronously interchange into the space previously occupied by the other (Fig. 27-1). The result of the position swap is a 90-degree reorientation of the common arm of the Z. Fundamental goals of the Z-plasty procedure include the realignment of a scar within RSTLs, or parallel to them; the lengthening of a scar; the release of a contracture by scar lengthening; and the dispersal of a scar for better camouflage.¹⁶

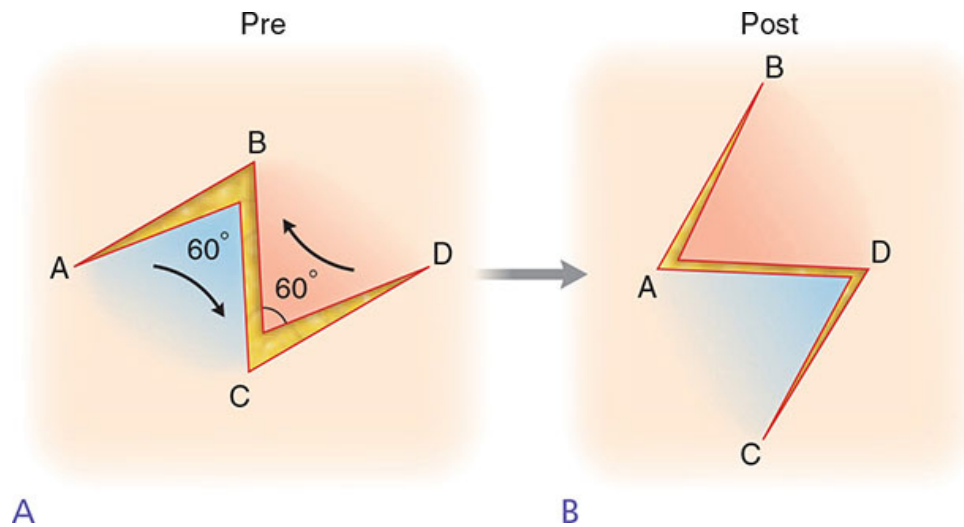


Figure 27-1. The classic Z-plasty. (A) The central limb of the original Z-plasty overlies the original scar. (B) After transposition of the triangular flaps created by the Z-plasty, the central limb is reoriented perpendicular to the original scar and parallel to the relaxed skin tension lines.

In its purest form, three incisions of equal length creating a Z, or its mirror image, are the integral steps in the execution of the technique. A central incision is made (in scar revision, this common limb overlies the original scar), and two adjoining limb incisions flank the central limb. It is important to note that although the surgeon has two choices for the placement of these lateral limbs, only one combination will allow for optimal cosmesis or reorientation of lines in the direction of, or parallel to, the RSTL (Fig. 27-2).¹⁷ Therefore, each incision's relationship to the RSTL is critical when planning Z-plasty to address scar orientation.

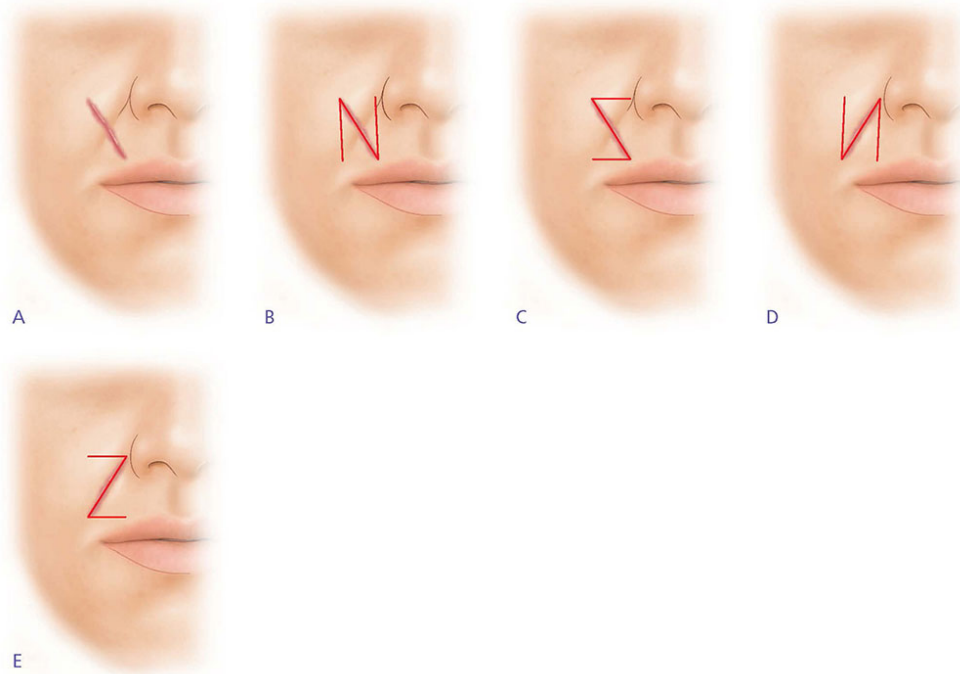


Figure 27-2. Z-plasty can reorient a scar 90 degrees. (A) A scar is oriented perpendicular to the right melolabial fold. (B) One choice for the Z-plasty is an incision line that lies over the original scar line and two adjacent vertical lines that serve as the limbs of the complete Z-plasty. (C) The other option for the Z-plasty is an incision line that overlaps the original scar and two horizontally placed incisions. (D) This figure represents the outcome of the transposition which takes place after the two triangular flaps in figure B exchange positions. The central limb now lies within the melolabial fold, now 90 degrees to its original position. Moreover, the two vertical incision lines fall within relaxed skin tension lines. This choice is favorable. (E) This figure represents the outcome of the transposition which takes place after the two triangular flaps in figure C exchange positions. Here, the horizontal incisions will not fall within the relaxed skin tension lines, essentially creating scars which will not hide within the natural contours of the facial lines. Note that both designs will reorient the original scar 90 degrees, to a position within the melolabial fold. However, one choice is clearly better than the other.

Another important factor in successful implementation of the Z-plasty is the angle created by the central and lateral limbs. Although angles from 30 to 90 degrees are possible, the 60-degree Z-plasty is the most common. As a general rule, the 60-degree Z-plasty should reorient the central scar by 90 degrees and yield a 75% increase in the length.

Classically, the Z-plasty consists of three equivalent incisions at 60-degree angles (Fig. 27-1). The central incision often overlaps the long axis of the scar, or alternatively the site of the defect if the scar is excised. After undermining the surrounding skin, the resultant triangular skin flaps are freed from the subcutaneous plane which lies below. The triangular flaps are then

exchanged so that the shared side of the triangles now lies against the skin of the lateral limb incisions and the resultant central limb is reoriented in a perpendicular fashion, ideally now parallel to RSTLs.

The Z-plasty procedure should not be used for every scar revision. If a scar already lies along RSTL, a Z-plasty may result in reorientation of the central incision perpendicular to the RSTL, typically a less desirable outcome. Similarly, scars within 40 degrees of RSTLs might be better managed with simple excision than with Z-plasty.¹⁸ Large Z-plasty approaches should generally be avoided given the substantial tension vectors that may exist across their common limbs; in such cases, multiple Z-plasty, as detailed below, would be preferable.

Z-plasty variants

Double-opposing Z-plasty includes two mirror image Z-plasty flaps placed immediately adjacent to each another (Fig. 27-3). After transposition of the triangular flaps, which naturally interdigitate with each other, there is a broadly based large flap with a preserved and intact vascular network. This application of the Z-plasty is primarily utilized in the areas of limited skin availability, laxity, or vascularity.¹⁹ As such, the technique is most useful in scar contractures, webs, or burns.

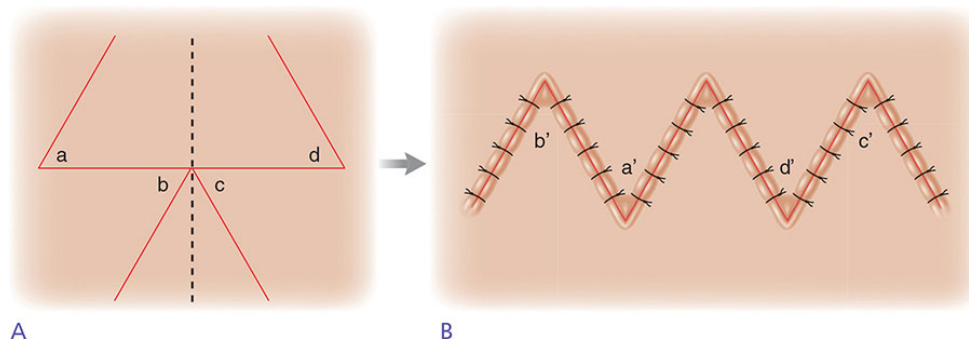


Figure 27-3. Double-opposing Z-plasty. (A) This modification consists of two mirror image Z-plasties placed immediately adjacent to one another. The *dotted line* represents the axis of reflection. Flap a and flap b swap positions and flaps c and d engage in a similar exchange. (B) The final result of the transposition. Since this application is primarily utilized in areas of limited skin availability, laxity, or vascularity, it is most useful in the treatment of scar contractures, webs, or burns.

The dancing man is a modification of the double- opposing Z-plasty technique (Fig. 27-4). Here, the Z-plasties share a common limb. First described by Mustardé, the dancing man has been primarily utilized in the epicanthal region²⁰ and later applied to the release of skin contractures.²¹

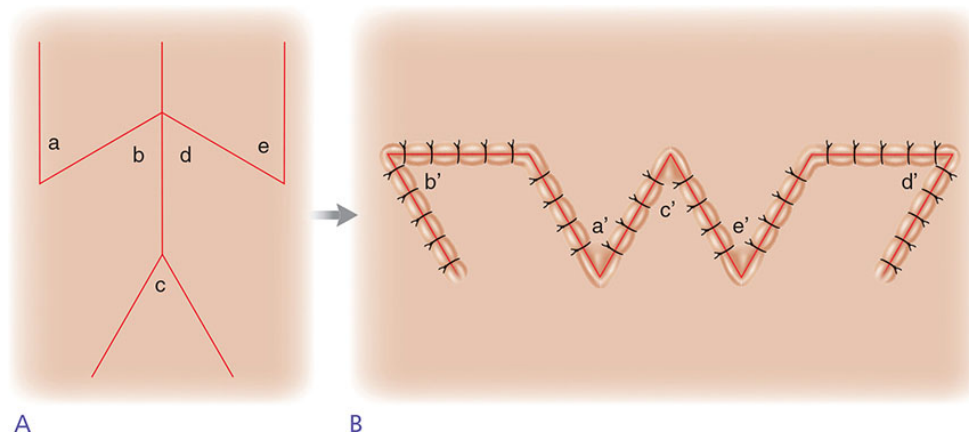


Figure 27-4. The dancing man. Mustardé's design shares components of the double-opposing Z-plasty. Note that the Z-plasties share a common limb.

The unequal triangle Z-plasty is another variation of the original Z-plasty technique (Fig. 27-5). Unequal triangular flaps are a result of a Z-shaped incision using nonparallel limbs and dissimilar angles between the limb incisions and the central incision. The half-Z is one example of this method, where one of the Z-plasty limbs is perpendicular to the central incision (Fig. 27-5C,D). The unequal angle approach is often utilized when there are different degrees of laxity in regional skin, such as the palpebral area or overlying scar tissue.

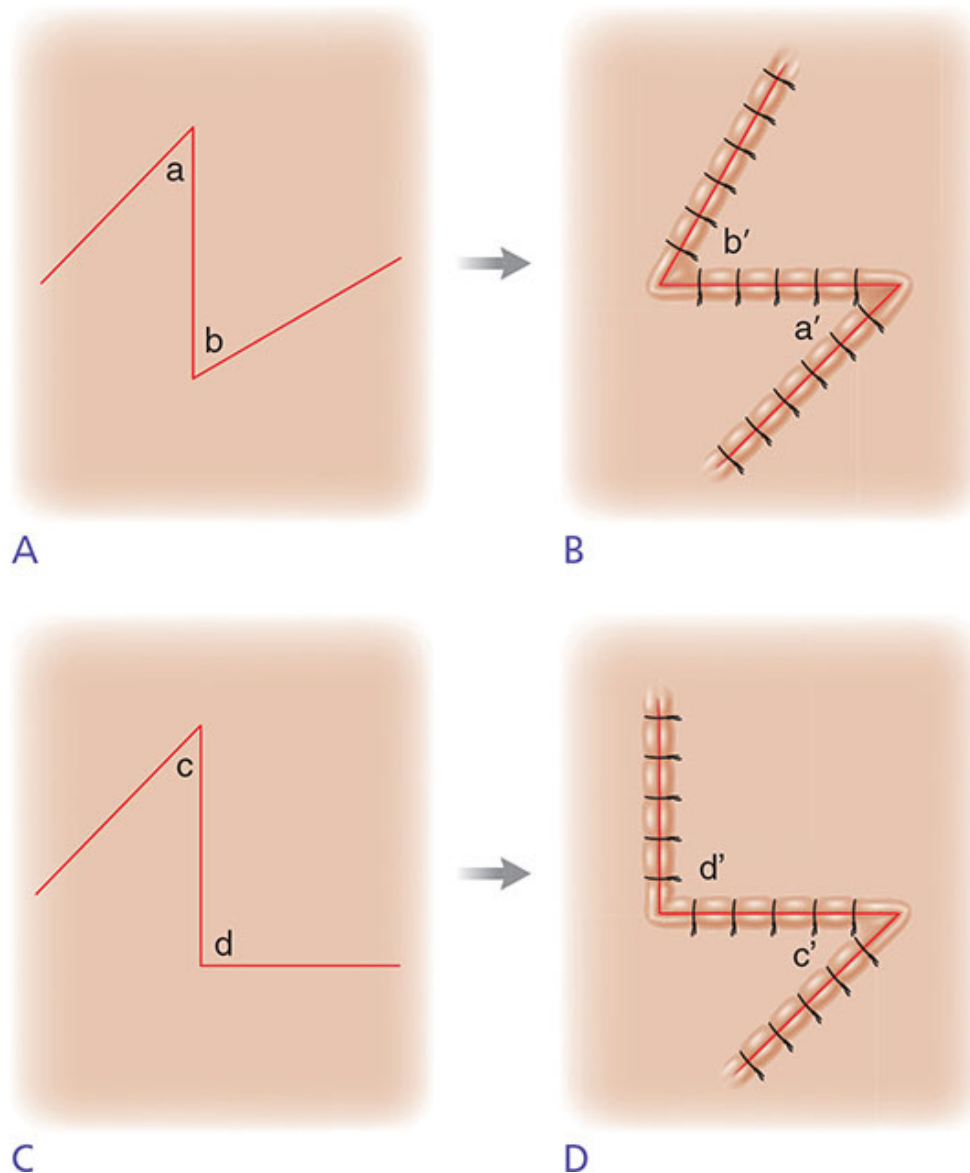


Figure 27-5. The unequal triangle Z-plasty. (A) Flaps are often designed to suit the area of reconstruction. Here, the flap angles vary. (B) The flaps swap positions, and the final placement is illustrated. (C) The half-Z-plasty is a modification of the unequal triangle Z-plasty whereby one of the two flaps is 90 degrees. (D) The flaps of the half-Z-plasty undergo transposition. Note that the unequal triangle Z-plasty is useful in areas where small amounts of tissue need to be moved with as little distortion as possible such as near the eyes or lips. This Z-plasty technique is particularly useful in areas where normal skin elasticity varies such as the eyebrows.

The unequal triangle Z-plasty has been adapted in innovative ways. Mutaft et al. designed the “reading man” procedure, a spinoff of the unequal triangle Z-plasty technique for the repair of circular defects of the skin (Fig. 27-6).²² The resultant incisions produce the silhouette of a man who is reading a book

held in his hand, and flap transposition results in effective closures for defects up to 14 cm in diameter.²² Consistent findings at mean follow-up of 15 months reveal durable skin coverage with fine scars in all patients.²²

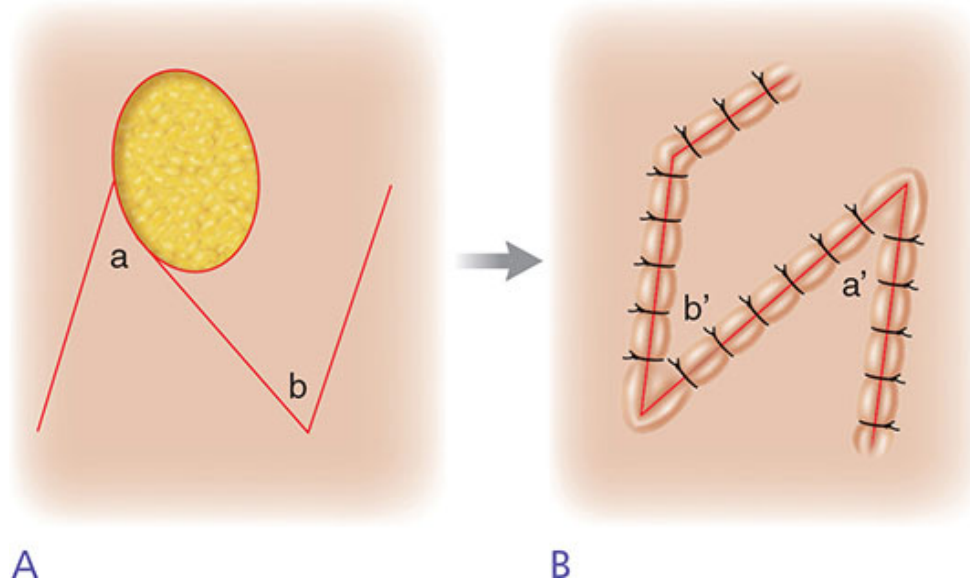


Figure 27-6. The reading man. (A) A modification of the unequal Z-plasty utilizes flap transposition to repair circular defects. (B) The outcome of the triangular flap exchange. The reading man has been utilized in the repair of large circular defects (1.5–14 cm in diameter) on the face and trunk.

The four-flap Z-plasty modestly redesigns the basic Z-plasty to include two extra limbs coming off the end of the central incision, thereby bisecting the original angles (Fig. 27-7). Traditionally, there are two types of four-flap Z-plasty, the 120 and the 90 degrees, with each angle divided in half to create four flaps. One of the greatest advantages of this technique is the considerable decrease in tension and increase in length it provides through the construction and subsequent transposition of four flaps.²³ It provides gains of length of two 60-degree Z-plasties (150% increase, at 75% per Z-plasty) or two 45-degree Z-plasties (100% increase, at 50% per Z-plasty) performed in parallel.²⁴ Consequently, this technique is often utilized at scar sites of the first interdigital web space of the hand and anterior and lateral neck where contractures often restrict areas of otherwise normal flexion. The four-flap Z-plasty releases these severe scar contractures through the additional length gained.

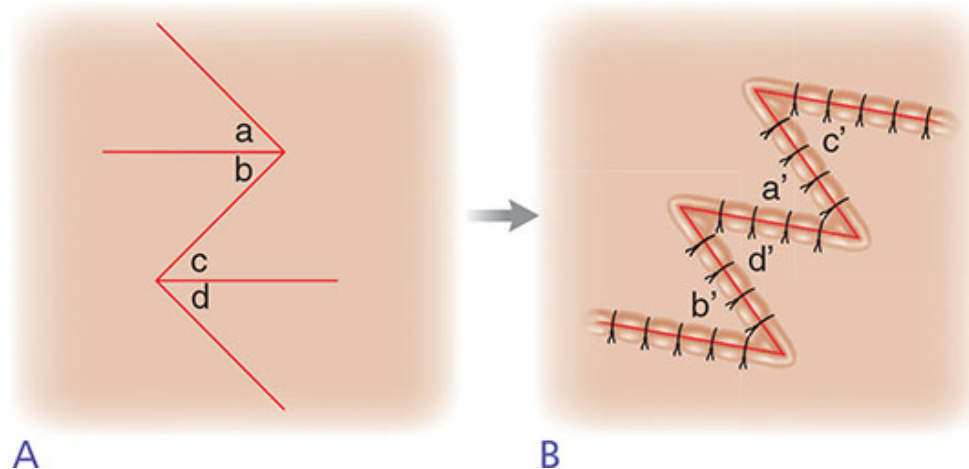


Figure 27-7. Four-flap Z-plasty. (A) An illustration of the four-flap Z-plasty shows 90-degree angles bisected into 45 degrees. (B) After flap transposition, each flap interdigitates with one another. The four-flap Z-plasty is commonly utilized in the release of web-space contractures.

The four-flap Z-plasty uncovers an important relationship: an increase in the number of transposition flaps yields greater gain in length. This relationship is also applicable to multiple Z-plasties arranged in series (Fig. 27-8). At times, often in the case of long contractures, multiple small Z-plasty in series is superior to the use of one large Z-plasty because though the theoretical amount of lengthening in the longitudinal axis along the central limbs are equivalent when comparing both methods, the compound Z-plasty provides less transverse shortening, along the lateral limbs on the horizontal axis and less tension across the common limb.²⁵ Therefore, for long linear scars, the multiple Z-plasty is recommended. This procedure aims to divide the central limb into segments which ultimately distribute the tension across various smaller transverse diagonals. The redirection of these forces may improve the appearance of the scar.

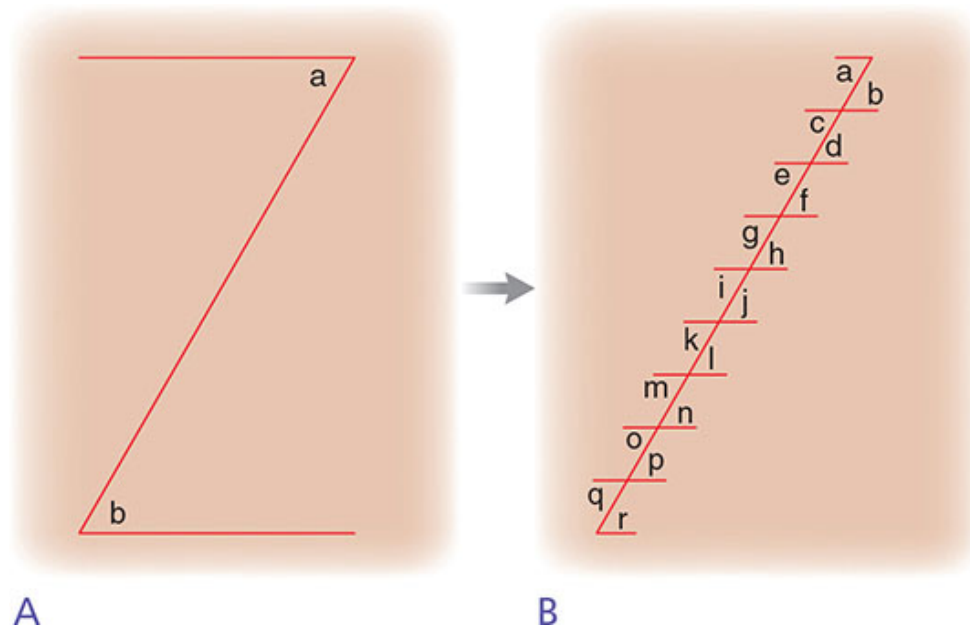


Figure 27-8. Multiple Z-plasty. (A) With longer linear scars, significant tension is substantial at the diagonal and arms of the Z, oftentimes decreasing the value of the single Z-plasty. (B) In the multiple Z-plasty, a long linear scar is divided into smaller segments each of which undergo separate Z-plasty, distributing the tension across many smaller transverse diagonals.

Some drawbacks to multiple Z-plasty relate to the degree of tension on adjacent flaps from neighboring transposition flaps. This not only adds to a reduction in the theoretical gain in length, but also leads to flap distortion. Multiple Z-plasty may lead to a sawtooth pattern when applied to a web.²⁶

The traditional Z-plasty technique and associated variations predispose the scar to stereometric elongation, that is, a bulging effects or dog-ear (standing cone) formation, particularly when performing Z-plasty on flat surfaces.^{27,28} Though normal tensile forces and the elasticity of the skin routinely counter the bulging effect, the outcome is not always flawless, and inelastic skin is most vulnerable to bulging. To circumvent these issues, Roggendorf in 1983 introduced the planimetric Z-plasty which allows for elongation only within the skin plane.²⁸ To achieve this, a Z-plasty with 75-degree angles is created with limb incisions twice the length of the central limb (Fig. 27-9). This central incision is then extended in both directions to create an imaginary diagonal line between the end of the lateral limb incision and the central limb, measuring twice the length of the original limb incisions. The two triangular areas that are created are excised prior to flap transposition. Roggendorf calculated that the efficacy of planimetric Z-plasty,

measured as the fraction of skin elongation to scar elongation, exceeds that of the classic Z-plasty by 28%.²⁸ In practice, it is challenging to predict the elongation effects due to patient and site characteristic differences. Nevertheless, it is advantageous that some parts of a scar can be excised by execution of planimetric Z-plasty. This approach is useful in the treatment of irregular scars with mild contracture.

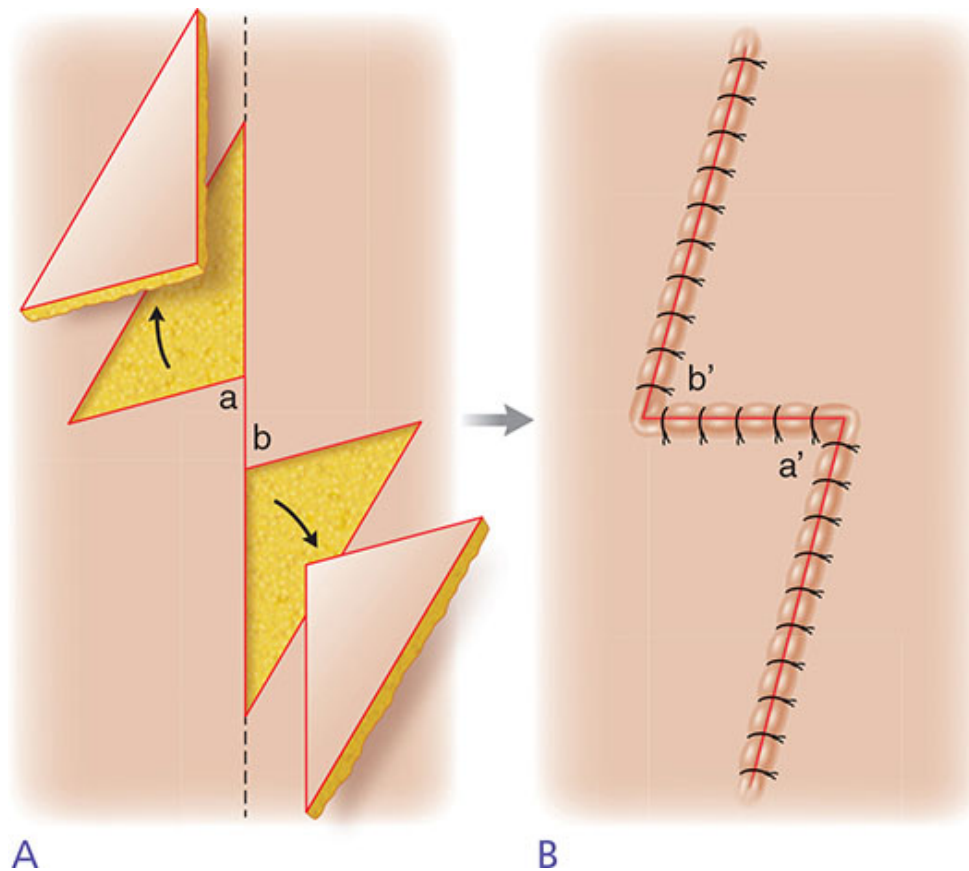


Figure 27-9. Planimetric Z-plasty. (A) 75-degree angles are utilized in this version of the Z-plasty. Limb incisions are twice the length of the central incision. Once the central incision is extended in both directions, two triangular areas are excised. (B) The effect of flap transposition. This technique is useful for correcting scars on flat surfaces and helps to avoid the elevations and depressions that can form with other types of Z-plasty, thereby creating smooth elongation of the skin along the scar axis.

Another Z-plasty variant is the spider procedure design. It converts a skin defect to an equilateral triangle with closure by five flaps harvested from the neighboring skin in a double-opposing Z-plasty manner (Fig. 27-10).²⁹

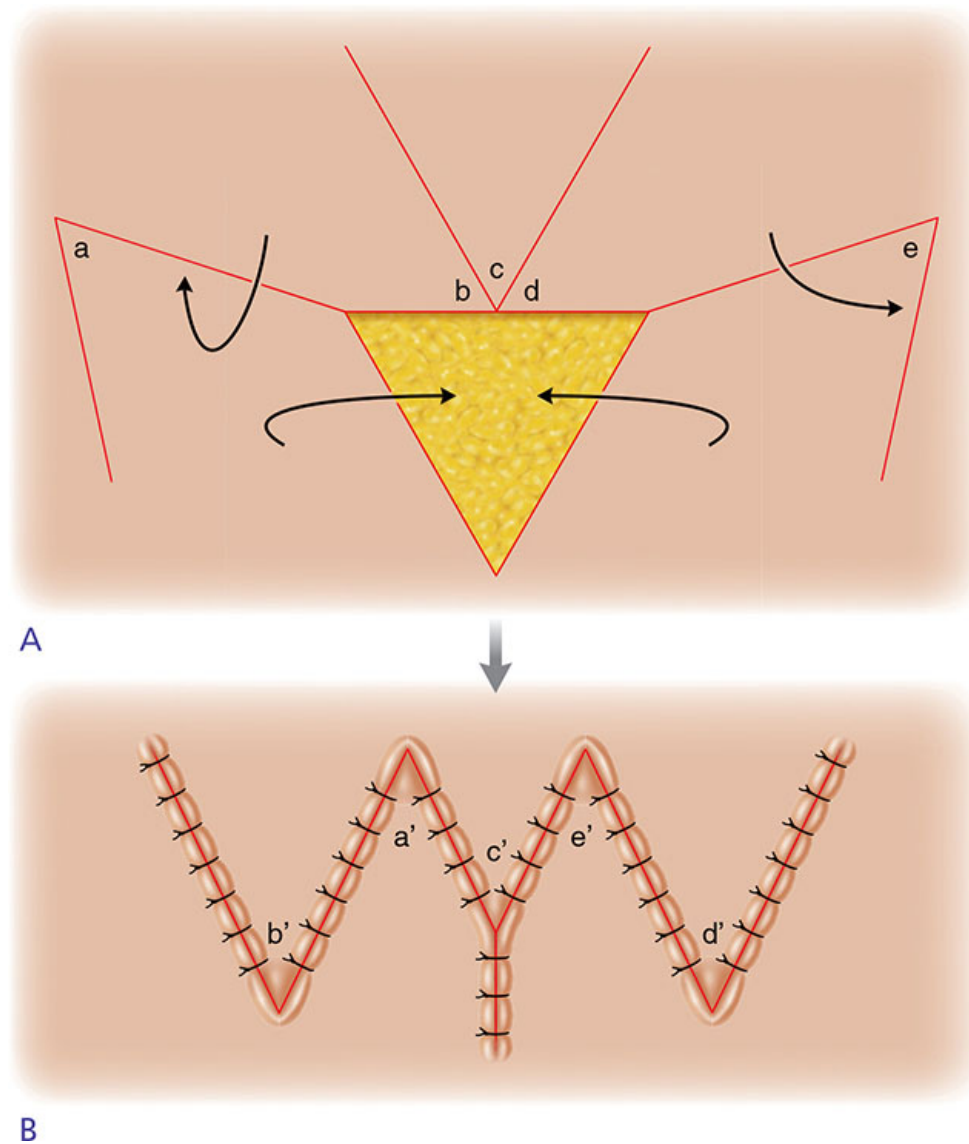


Figure 27-10. The spider procedure. (A) The illustration presents a triangular defect and incisions, which result in the formation of five flaps. Arrows signify the directions of the planned transpositions to repair the triangular defect. (B) The diagram is a representation of the final result of the spider procedure, after all flap transpositions take place. After converting skin defects to equilateral triangles, this technique can be utilized in the closure of defects in high-tension locations.

The Z-plasty aims to improve the appearance of the scar, relieve tension during wound closure, and correct scar contractures (Figs. 27-11 to 27-13). In the treatment of scars and contractures, the most appropriate design must be selected from the many options available to the dermatologic surgeon. It has been suggested that the greatest advantage of the Z-plasty is replacement

of an existing unattractive scar opposing RSTLs with a new scar which conforms to these lines,³⁰ though not all evidence supports this notion.¹⁵



Figure 27-11. Z-plasty utilization in web correction. (A) Postprocedure photo of a primary defect near the medial canthus. (B) The photo illustrates the late sequelae of scarring near canthal folds. Oftentimes, treated lesions near the medial canthi predispose to surgical webs. (C) Medial and lateral canthal webs can be corrected with Z-plasty. Superimposed “Z” represents the required incisions for surgical correction. Note that the central limb of the Z overlies the primary problematic tension band. (D) After the flaps undergo transposition, tension is relieved. (E) A photo of the web repair with Z-plasty as noted during his follow-up appointment.



A



B



C



D



E

Figure 27-12. Z-plasty utilization in medial ectropion repair. (A) Photographic illustration of a left medial ectropion. (B) Mapping of vectors for Z-plasty with surgical marker ink. (C) After the incisions are performed, triangular flap transposition occurs for proper execution of the Z-plasty technique. (D) Postprocedure photo representing the final result of the Z-plasty technique in the repair of a medial ectropion. Note the presence of a Frost suture for stabilization. (E) Photo of ectropion repair with Z-plasty as documented during patient's follow-up appointment.



Figure 27-13. Scar contracture repair and eyebrow asymmetry treated with Z-plasty. (A) Photograph of left malar eminence scar contracture in female patient. Also note patient's eyebrow asymmetry. (B) Mapping of a multiple Z-plasty across the right lateral forehead to correct brow asymmetry. (C) Immediate postoperative appearance. (D) The patient at a follow-up appointment. Note the absence of scar contractures at the operative site of the Z-plasty and correction of the brow asymmetry.

The evaluation and planning of the Z-plasty procedure is influenced by more than simple geometry.¹⁷ Outcome predictions are a combination of formulaic skin biomechanics and intuition. Though the principles of flap dynamics are a function of skin mobility and deformability under tension, differing skin extensibility, or laxity, impacts the end result. Clinical studies by Gibson and Kenedi showed lengthening ranged from one-third less to two-thirds more than expected from their geometric calculations.³¹ This large degree of variability points to the fact that geometry alone is not a predictive measure of outcomes. Other studies have demonstrated similar findings.^{32–34}

Complications

Though Z-plasty is a useful tool, complications do occur. The manipulated skin can be vulnerable to flap necrosis and hematoma formation, the former of which is common in Z-plasty with angles less than 30 degrees and with flap tips which necessitate frequent handling.^{17,35} Therefore, it is best to avoid the use of Z-plasty with such acute angles and minimize direct manipulation of triangular flap tips when possible.

CONCLUSIONS

Familiarity with the Z-plasty approach provides the surgeon with a useful tool to release contracted scars and reorient scars that are not located within RSTLs. Though breaking up a long scar into smaller, less noticeable segments has been espoused as a benefit of the Z-plasty, evidence that it accomplishes this purpose is anecdotal. The Z-plasty is an essential tool for the dermatologic surgeon when considering web and free-margin correction.

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CHAPTER 28 Skin, Cartilage, and Composite Grafts

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SUMMARY

- With the exception of ear and large lower extremity defects, grafts are usually a second- or third-line option for surgical repairs, as primary closure, flap closure, and second intention healing may result in superior cosmesis.
- Cartilage grafts may be very helpful for recreating the ala and preventing notching as well as ensuring adequate valve function.

- Grafts may be used as solitary closures, as adjuncts to other repairs such as flaps, and as a rescue approach when a linear repair is under excessive tension.

Beginner Tips



- Widely undermine the FTSG recipient site to minimize the risk of a pincushion deformity.
- Meticulous suturing techniques to maximize contact of the skin graft with the wound bed should be employed.
- The antihelix is an excellent cartilage graft donor site with minimal cosmetic or functional penalty.

Expert Tips



- Grafts designed to cover Mohs defects can be harvested at a 45-degree angle to match the angle of the bevel used during the Mohs procedure.
- Composite grafts are ideal for small, deep wounds that involve a skin and cartilage defect, but should not be used on larger defects.

Don't Forget!



- Delayed skin grafting over areas of exposed bone or cartilage can be used to improve chances of graft survival.
- A graft with superficial necrosis is not necessarily doomed; careful wound care and watchful waiting can still result in a satisfactory final outcome.
- Shearing forces are the primary adversaries of graft success.

Pitfalls and Cautions



- Meticulous hemostasis must be performed in the wound bed prior to graft placement to ensure that hematoma does not interfere with the graft's contact with the nutrient-rich wound bed
- Failure to place fenestrations within an STSG can increase the chance of serosanguinous fluid pooling and graft necrosis.
- The use of an FTSG for a wound >5 cm or a wound with a tenuous blood supply is not recommended due to risk of graft necrosis.

Patient Education Points



- Even perfect graft selection and surgical technique cannot prevent graft failure in patients with heavy tobacco use.
- Lack of patience in awaiting graft maturity before the 3-month postoperative time point can result in unnecessary stress and scar refinement procedures. Regular follow-up and reassurance are key.

Billing Pearls



- Skin grafts are coded based on location, involved tissue, and size.
- STSGs are coded with the 15100 series; FTSGs with the 15200 series; cartilage grafts from the ear are coded as 21235; and composite grafts are coded as 15760.
- Donor site closure is included in the graft coding.
- If two separate graft types, or a graft and flap, are performed on the same day, they should both be coded, though they are subject to the multiple-procedure reduction rule.
- There is a 90-day global period associated with these codes.

CHAPTER 28 Skin, Cartilage, and Composite Grafts

INTRODUCTION

The use of skin grafts dates back to Hindu culture over 3000 years ago when the Tilemaker caste in India reported the successful use of skin grafts from the buttocks to repair defects of the nose, lip, and ear caused by mutilation as punishment for crimes such as adultery and theft.^{1,2} The first reports of successful full-thickness skin graft (FTSG) and split-thickness skin graft (STSG) use in the Western world did not appear in published works until the 19th century.¹

Although primary closure and local flaps are typically favored to reconstruct post-Mohs surgical defects for optimal color and texture match, skin grafts play an important role in dermatologic surgery. The practicing dermatologic surgeon should be skilled in the selection, harvesting, and placement of FTSGs, STSGs, cartilage grafts, and composite grafts. Skin grafts can be used for the reconstruction of a broad range of surgical defects of varying sizes, shapes, and depth across the entire cutaneous surface.

Classification

Skin grafts can be described as split thickness when they contain the entire epidermis and a portion of the dermis with few or no adnexal structures. FTSGs contain the entire epidermis and dermis as well as adnexal structures. Cartilage grafts, as the name implies, contain cartilage and are typically harvested from the ear in dermatologic surgery. Composite grafts contain the entire epidermis and dermis, as well as adnexal structures and cartilage.

Indications

Skin grafts are selected when repair with primary closure, flap repair, or healing by second intention are not viable options, or are deemed to be inferior options for the surgical patient. Skin graft repair is performed in almost 10% of Mohs reconstructions, and tends to follow a greater number of Mohs layers for tumor extirpation than the number of layers required when linear repair, local flaps, or granulation is selected.³ Skin graft repair may also be chosen in some patients over local flap repair when optimal cosmesis is not the primary goal of reconstruction or when patient preference dictates a simpler single-stage procedure over a multi-stage interpolation flap.

Pathophysiology

Skin, cartilage, and composite grafts are completely removed from their underlying supporting vascular structures and transplanted to a foreign wound bed where revascularization connecting the wound bed to the graft must successfully take place for graft survival. The metabolic requirements of skin grafts are directly related to their thickness; thus STSGs have a lower metabolic demand than FTSGs, which in turn have a lower metabolic demand than composite grafts.

The stages of skin graft healing can be divided into three stages: imbibition, inosculation, and neovascularization. There may be significant overlap between these stages. Imbibition is the first stage of graft survival that occurs during the first 24 to 48 hours of graft placement.⁴ During this phase, the graft is ischemic, and graft survival is dependent on local plasma exudate of the recipient wound bed which enters the graft by passive diffusion and increases the graft weight by up to 40%.⁵ Fibrin forms beneath the graft, keeping the graft in contact with the wound bed. The second stage of graft survival, inosculation, begins approximately 48 to 72 hours after graft placement, and is characterized by the growth of new capillaries from the recipient bed that anastomose with the vasculature of the donor graft.⁶ Because the graft recipient site must be well-vascularized prior to graft placement for this step to occur, graft recipient sites with exposed bone or cartilage where periosteum or perichondrium have been stripped often

benefit from delayed grafting to allow granulation tissue to form in the wound bed prior to graft placement.⁷ The final stage of graft survival, neovascularization, occurs in conjunction with inosculation, with completion 7 to 10 days after graft placement. Neovascularization describes the achievement of capillary ingrowth and anastomosis between the wound bed and graft with re-establishment of lymphatic flow.⁶⁻⁸ Postsurgical reinnervation of skin grafts has been demonstrated on a molecular level.⁹ However, clinically significant reinnervation of grafts is modest, with less than a third of patients with skin grafts on the face able to detect light touch 2 years after graft placement.¹⁰

PREOPERATIVE CONSULTATION AND CONSIDERATIONS

Adequate preoperative consultation is paramount for patient education and postoperative satisfaction. Realistic expectations must be set regarding tissue color and texture match, and all patients should be counseled that even the most ideally matched skin graft will leave scar lines. Patients should also be counseled that the appearance of skin grafts generally improves with time, and that the cosmesis of grafts and scar lines can be improved with chemical peels, dermabrasion, and ablative or nonablative laser therapies in the postoperative period.

Intrinsic and extrinsic factors that will affect graft survival should be discussed, particularly those that are amenable to behavioral modification. Patients with peripheral vascular disease should be counseled that their graft survival may be inferior compared to those in healthy patients, particularly if graft placement is on the distal extremities. Smoking has been shown to impede wound healing and increase the rate of graft and flap necrosis.^{11,12} Studies suggest that the short-term vasoconstrictive effects of nicotine abate within 48 hours of nicotine withdrawal.^{13,14} Although no consistent guidelines regarding smoking cessation after graft placement exist, smokers may be counseled on the benefits of smoking cessation at least 1 week preceding graft placement and for 1 week postoperatively, with the ideal period being as long as the patient is able to abstain, as adequate blood flow

to the delicate anastomosing capillary network of the wound bed and graft in the weeks following surgery is vital.

All nonprescription medications and supplements that can increase bleeding risk in the postoperative period should be discontinued with the following recommendations:¹⁵

- Ephedra: 24 hours
- Gingko: 36 hours
- Alcohol: 2 days
- Ibuprofen: 2 to 5 days
- Ginseng, garlic, vitamin E: 1 week

Aspirin should not be discontinued if a physician has prescribed it. If aspirin has not been prescribed by a physician, use should cease at least 1 to 2 weeks preoperatively.⁷ Although the bleeding risk in patients on warfarin and other anticoagulants is higher than that of those not on anticoagulation, the risk remains low.¹⁶ Prescription anticoagulants, including warfarin, antiplatelet agents, direct thrombin inhibitors, and direct factor Xa inhibitors should not be discontinued preoperatively to avoid potentially dangerous thrombotic events.

Complications

The most common complications during the postoperative course of graft healing are hematoma, seroma, necrosis, and infection. Hematoma formation can be avoided by meticulous hemostasis and avoidance of all nonessential anticoagulants. The graft and wound bed should be in complete contact, and shearing forces should be minimized in order to optimize the chances of graft survival and minimize the risk of hematoma and seroma. This can be achieved by skillful placement of sutures that are placed first through the graft, then through a section of the wound bed, and finally back through the skin edge before the suture knot is tied. Basting sutures through the center of the graft are commonly used to improve contact of the skin graft with the wound bed and allow for optimal imbibition, inosculation, and neovascularization. Skin graft fenestrations may be utilized, particularly in large grafts, to allow for drainage of blood and serous fluid that would

otherwise compromise contact of the graft with the wound bed. Bolster dressings made of plain or petrolatum-impregnated gauze, dental rolls, or cotton balls either tied on or kept in place with adhesive material can also be employed to maximize graft contact with the wound bed (Fig. 28-1). Although bolster dressings are commonly used, there is no evidence supporting superior graft survival with their use.^{17,18}



Figure 28-1. A bolster dressing is placed to maximize contact of the FTSG with the wound bed.

If adequate blood supply cannot be established between the graft and the wound bed, full or partial graft necrosis may occur. The risk of graft necrosis can be mitigated by the same tactics used to minimize seroma and hematoma formation, in addition to smoking cessation. Graft necrosis is often heralded by the formation of a black eschar. Should this occur, gentle debridement should be performed. Often, a necrotic-appearing graft manifests only partial-thickness necrosis, and can still heal with excellent cosmesis once the superficial slough is eliminated and re-epithelialization takes place with the aid of daily gentle cleansing and application of petrolatum ointment (Fig. 28-2). Given their increased metabolic demand, composite and FTSGs are at higher risk for necrosis than STSGs.

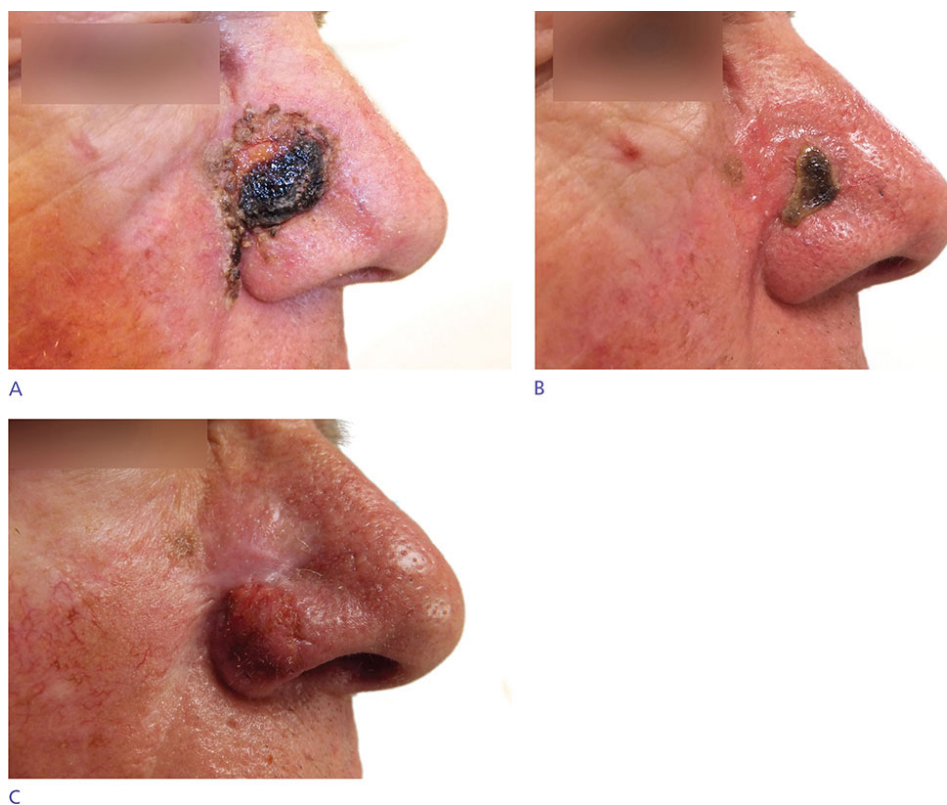


Figure 28-2. (A) A partially necrosed FTSG. (B) The partially necrosed FTSG is healing well with conservative wound care. (C) The once-necrotic FTSG has healed with an atrophic scar. The patient incidentally has an additional FTSG on the nasal ala after a subsequent Mohs surgery that is healing well.

The signs of wound infection include warmth, erythema, edema, purulent drainage, and a putrid odor. Wound infection has the potential to compromise skin graft healing. If a wound infection is suspected, a bacterial culture

should be obtained and oral antibiotics directed at the causative organism should be started.

Contraindications

If a surgical wound bed does not have an adequate blood supply, such as in an area of bone or cartilage devoid of periosteum or perichondrium, a skin graft is unlikely to survive. To improve the chances of graft survival and optimize cosmesis, delayed grafting may be considered to allow the wound bed to revascularize and form granulation tissue that will serve as a rich nutrient bed for the incipient graft.^{19,20} A hinge flap can also be utilized, where a flap of muscle or fat adjacent to the defect is incised with its vascular pedicle intact and inset over the surgical defect to allow for immediate graft placement (for a full discussion of hinge flaps, see [Chapter 43](#)).^{21,22}

FULL-THICKNESS SKIN GRAFTS

FTSGs are indicated when a surgical defect is unable to be repaired by primary or flap closure techniques and when second intention healing is likely to result in a poor cosmetic or functional outcome. FTSGs are commonly utilized to repair defects on the nasal tip, nasal ala, ear, medial canthus, eyelids, digits, and scalp ([Fig. 28-3](#)).²³ FTSGs are thicker and thus more metabolically demanding than STSGs, though FTSGs are able to restore full skin contour and offer a better cosmetic appearance than STSGs. FTSGs are able to cover defects up to 4 to 5 cm in diameter before the risk of graft necrosis due to overwhelming metabolic demand becomes significant, whereas STSGs are able to cover much larger defects.⁷



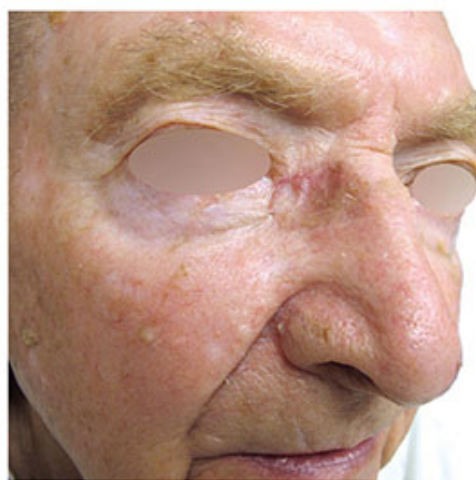
A



B



C



D





Figure 28-3. (A) A patient with a large nasal tip defect who declined paramedian forehead flap repair is repaired with an FTSG from the neck. Graft survival and acceptable cosmesis are apparent at suture removal, 6-week follow-up, and long-term follow-up. (B) A patient with a defect on the nasal ala is repaired with an FTSG harvested from the conchal bowl. (C) A defect on the helical rim is repaired with an FTSG harvested from the preauricular skin. Graft survival at suture removal 1 week postoperatively and excellent long-term cosmesis are observed. (D) A patient with a defect extending from the right medial canthus onto the right nasal sidewall is repaired with an FTSG from the mandible. Postoperative ecchymosis is present at suture removal. Excellent long-term cosmesis is achieved. (E) A defect on the posterior auricle is repaired with an FTSG from the postauricular neck. Basting sutures are placed to optimize contact of the FTSG with the wound bed. (F) A defect of the triangular fossa of the ear is repaired with an FTSG from the neck. Normal color changes are observed at suture removal 1 week postoperatively. At 6-week follow-up, almost complete healing is achieved. At long-term follow-up, the graft is healed with a slightly atrophic scar.

Graft selection

The donor site should be selected carefully from an area of skin with similar color, texture, thickness, background photodamage, degree of sebaceousness, and degree of hair density as the skin surrounding the surgical defect. The graft donor site should be selected from an area where harvesting of the graft will not cause significant functional or cosmetic compromise, and where the donor site scar can be easily concealed. When an optimal match is not possible between the skin appearance of the donor and recipient site, poor cosmetic outcome is more likely to occur.

FTSGs are commonly used on concavities and convexities of the upper two-thirds of the ear, where they can provide excellent topographic and contour restoration.²⁴ Although a combination of a cartilage graft with an FTSG may be necessary for defects where a significant portion of the helical rim cartilage has been removed, FTSGs can frequently be used alone for defects of the remainder of the ear when helical rim cartilage is intact. The preauricular sulcus, postauricular sulcus, and postauricular neck tend to have similar color and baseline photodamage as the ear, making them ideal donor sites for defects of the helix, anterior ear, and posterior ear.

While local flaps are often the preferred reconstructive option for defects on the nose for optimal cosmesis, FTSGs provide a straightforward repair and closure option and an acceptable cosmetic outcome for many patients. For defects on the nasal tip and ala, the conchal bowl is a common FTSG donor site owing to its similar color and sebaceousness. Furthermore, providing the perichondrium is left intact, wounds in the conchal bowl are able to granulate well and heal by second intent with minimal cosmetic penalty.

Defects of the nose that are too large for a conchal bowl graft are often repaired with FTSGs from the preauricular sulcus or postauricular neck where the degree of photodamage is similar to the nose and scars can be easily concealed. For defects of the lower eyelid, FTSGs from redundant skin of the upper eyelid, harvested using a blepharoplasty-type technique, can be utilized with favorable tissue match. Other common FTSG donor sites used for larger defects of the face, scalp, and extremities are the clavicle and inner upper arm (Table 28-1).

Table 28-1. Common FTSG Donor and Recipient Locations

Defect Location	FTSG Donor Site
Nose	Conchal bowl, preauricular cheek, postauricular sulcus, postauricular neck
Ear	Postauricular sulcus, postauricular neck, preauricular cheek
Lower eyelid	Upper eyelid
Medial canthus	Upper eyelid, postauricular sulcus, preauricular cheek
Scalp	Postauricular sulcus, postauricular neck, supraclavicular, upper inner arm

Technique

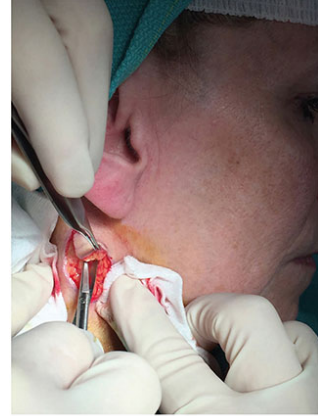
The donor site is first scrubbed with antiseptic and anesthetized. The surgical defect is then measured in both horizontal and vertical dimensions and a graft template is drawn with a surgical marking pen on the donor site. If the graft donor site is to be closed primarily, the standing cones to be removed can be drawn at the same time. It is recommended to oversize the harvested graft 10% to 20% to account for tissue contraction and ensure a final graft that is sufficiently sized for the surgical defect (Fig. 28-4).



A



B



C



D



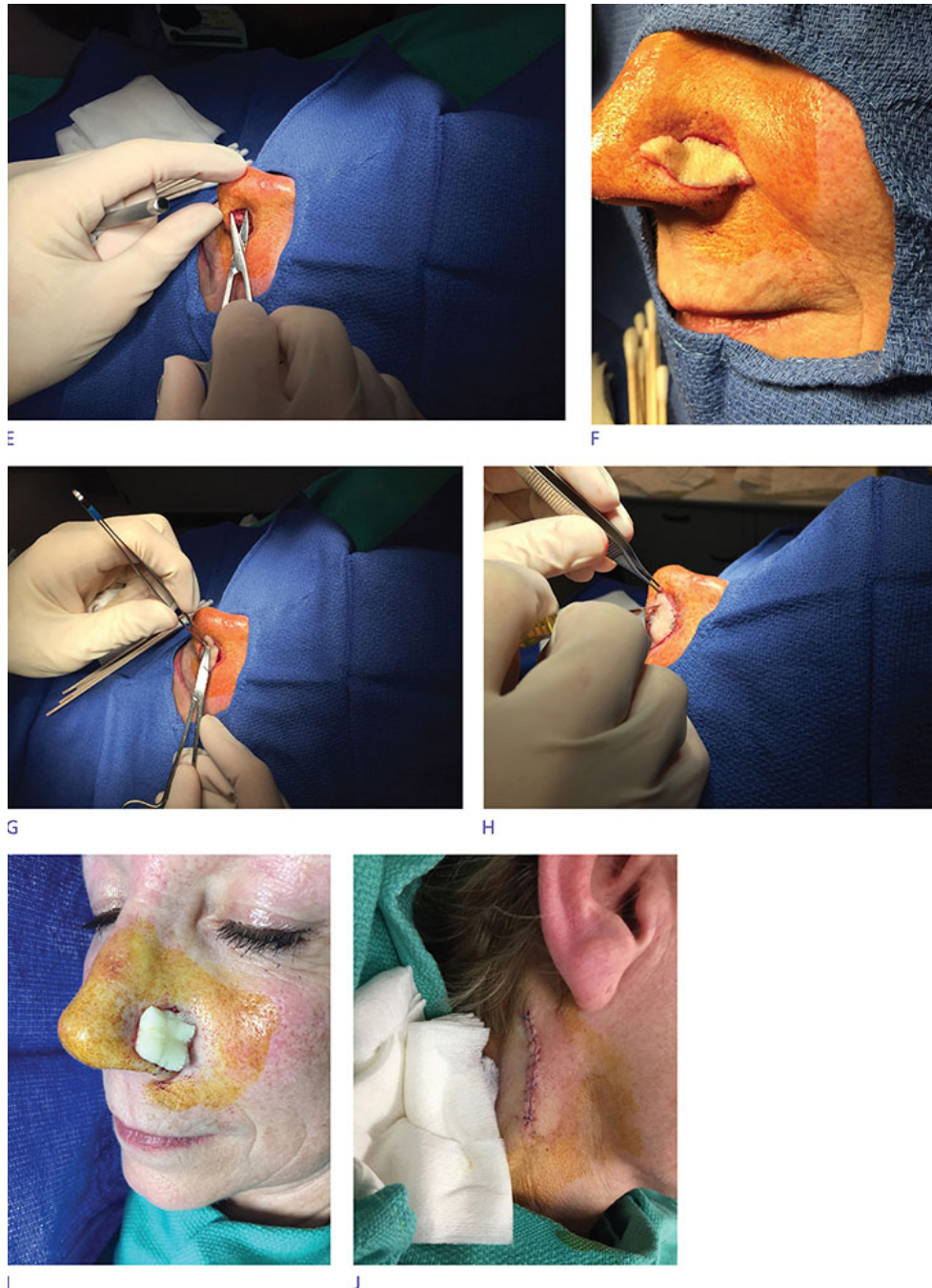


Figure 28-4. Step-by-step FTSG repair. (A) A surgical defect on the left nasal ala is present after Mohs micrographic surgery for a basal cell carcinoma. (B) The defect is measured and a template is drawn on the neck, which has been selected as the FTSG donor site. (C) The donor site skin is excised in a standard fashion. (D) Iris scissors are used to de-fat the FTSG until shiny white dermis is visible across the graft. (E) The surgical defect is undermined to minimize postoperative pincushion deformity. (F). The FTSG is placed on the recipient wound bed. (G) The graft is sutured in place with anchoring sutures. (H) The FTSG is trimmed to perfectly fit the surgical defect. (I) Remaining sutures are placed (not pictured) and a bolster dressing is placed as desired. (J) The FTSG donor site is repaired with a standard layered closure.

A no. 15 Bard-Parker scalpel is used to excise the donor graft tissue with or without the planned standing cones. If the surgical defect to be repaired is a defect from Mohs micrographic surgery, beveled edges are usually present in the wound bed. If the beveled edges are maintained, the graft should be harvested at a 45-degree angle for optimal fit.²⁵ If the graft is excised at the standard 90-degree angle, the wound edges of the Mohs surgical defect should be trimmed to reflect right angles, so the graft may optimally fit in place.

The donor site is excised down to the level of the adipose tissue, with the exception of the conchal bowl graft, which is excised to the level of full dermal thickness down to cartilage, leaving perichondrium intact. Immediately after excision, the graft is placed in a small sterile basin containing sterile saline, and hemostasis is achieved at the graft donor site.

The graft is then placed epidermis down with subcutaneous fat exposed over the gloved nondominant hand or over a gauze pad in the nondominant hand. The harvested graft is traditionally de-fatted with curved iris scissors until white shiny dermis is exposed over the entire skin graft. It should be noted that although de-fatting is a standard practice in dermatologic surgery to minimize the risk of graft necrosis, retaining 1 to 5 mm of subcutaneous fat on FTSGs may be considered with pleasing aesthetic results, particularly for the repair of deeper defects on the lower one-third of the nose.²⁶

The skin edges of the recipient wound bed are then undermined to minimize potential postoperative pincushion deformity. The graft is accurately positioned over the wound bed, and simple interrupted sutures are placed at opposite ends of the graft to secure it in place. Meticulous hemostasis must be performed in the wound bed prior to graft placement to ensure that hematoma does not interfere with the graft's contact with the nutrient-rich wound bed. Depending on graft location, 6-0 polypropylene, 5-0 polypropylene, or 5-0 fast-absorbing gut sutures are favorable sutures to secure the graft.

Iris scissors are used to trim the graft to the exact size of the wound bed, and additional simple interrupted sutures are placed to secure the graft. The suture is first placed through the graft and then through the donor skin to maximize accurate approximation and minimize trauma to and displacement of the graft. Sutures should be placed down to the level of the reticular dermis of the graft and donor site skin to anchor the graft to the wound bed

for optimal graft survival and to reduce the risk of depressed scar lines.²⁷ Central basting sutures may also be placed to maximize graft contact with the wound bed. For larger grafts, a running suture may also be used once several anchoring sutures are placed evenly around the periphery of the graft.

The donor site is then repaired in a standard fashion using a layered closure technique. If a conchal bowl graft is harvested, the graft donor site is left to heal by second intention. If a delayed FTSG is performed, the graft is placed over the granulating wound bed 2 to 4 weeks after surgery. Before graft placement, the wound bed is first curetted down to a healthy base, and the skin edges are freshened by excising 1- to 2-mm margin of the wound edge.¹⁹

Burow's grafts

A Burow's graft is most commonly used when a wound cannot be completely closed primarily or when closing a wound primarily would distort a free anatomic margin such as the alar rim, lip, or eyelid (Fig. 28-5). The Burow's graft allows for the use of skin of a similar texture and color. This graft can also be used for defects that span two cosmetic units, allowing the first unit to be closed primarily and the second to be grafted with skin of optimal visual match.^{27,28}



Figure 28-5. A BCC is observed on the left alar crease (A) and a surgical defect is created after tumor extirpation with Mohs micrographic surgery (B). A Burow's graft is used to close the central portion of the wound in order to avoid alar distortion that would have resulted if the wound was closed primarily (C). Excellent cosmesis is achieved at suture removal (D).

To perform a Burow's graft, the standing cone removed from the partial primary closure is used to repair the residual defect rather than being discarded. Graft placement technique is the same as that used for the conventional FTSG. In hair-bearing areas such as the mustache, beard, and scalp, Burow's grafts can be particularly useful to restore normal hair growth within the surgical defect, and this graft may be conceptualized as a localized hair transplant procedure.

Cosmetic considerations

Graft contraction is common, and FTSGs may contract on average up to 30%. Grafts on the nose and periorbital area are most prone to contraction.²⁹ Pincushion deformity and hypertrophic scars may also occur at graft sites. Although color match of FTSGs with their recipient sites usually improves

over time, hyper- or hypopigmentation may be persistent, particularly if the FTSG is harvested from an area with suboptimal color match. Hypertrophic scars and pincushion deformities can be improved with intralesional steroid injection, while contour irregularity and color match can be improved with dermabrasion (Fig. 28-6), ablative lasers, medium-depth chemical peels, or a combination of these therapies.



Figure 28-6. Initial suboptimal postoperative contour and color match of this patient's FTSG (A) are improved after dermabrasion (B).

SPLIT-THICKNESS SKIN GRAFTS

STSGs are composed of epidermis and a portion of dermis, but do not usually contain hair or adnexal structures. STSGs generally range in thickness between 0.125 and 0.75 mm, and can be classified based on the amount of dermis in the graft as thin (0.125 to 0.275 mm), medium (0.275 to 0.4 mm), or thick (0.4 to 0.75 mm).²³

STSGs have lower metabolic requirements than FTSGs or composite grafts, and can be used to cover defects >5 cm. They are more likely to survive in wound beds with a suboptimal vascular supply, and are typically used to cover large wounds that would be slow to granulate and cannot be repaired by local flap or FTSG closure (Fig. 28-7). Moreover, in locations at high risk for tumor recurrence, STSGs offer the benefit of providing a thin “window” covering that can allow for straightforward monitoring of tumor recurrence under the graft.²³ STSGs can also be fenestrated, either manually or by a meshing device, to increase their surface area. STSGs are aesthetically inferior to FTSGs and local flaps, and do not usually offer ideal color or texture match with the surrounding skin. STSGs contract more than

FTSGs, and once healed usually appear as atrophic white or hypopigmented patches without visible adnexal structures.



A



B

Figure 28-7. (A) A large surgical defect of the lower leg is repaired with an STSG. The healed final wound is pictured. (B) A large surgical defect after Mohs micrographic surgery for a basal cell carcinoma of the forehead is repaired with an STSG harvested from the thigh. This patient had minimal surrounding skin laxity secondary to multiple previous surgeries for nonmelanoma skin cancers as a result of radiation therapy for acne during adolescence. The graft is observed to be healing well at suture removal.

Graft selection

The donor site of an STSG heals by second intention. Donor-site scars usually appear as a hypopigmented patch, although in darker skin types these can heal as a hyperpigmented patch. STSG donor-site scars are typically >5 cm, and thus STSGs should be harvested from areas that can be easily covered by clothing such as the abdomen, lower back, hips, buttocks, thighs, and proximal arms. The patient should be counseled that pain at the donor site is usually worse than that experienced at the recipient site.

Technique

STSGs can be harvested with a no. 10 blade, Weck blade, or electric dermatome. The donor site is scrubbed with antiseptic and then anesthetized. The defect is measured, and a corresponding template is drawn on the donor site with surgical marking pen. If the STSG will be meshed with a meshing device to cover a very large defect, the graft can be undersized by 25% to 35%.⁷ If the STSG will not be meshed, the graft should be oversized by 10% to 20% to account for tissue contraction and ensure adequate wound coverage. Although STSGs contract to a greater extent than FTSGs, they can still be oversized to the same degree as FTSGs. STSGs may be uniformly fenestrated to allow for the outflow of blood and serous drainage, thus increasing their potential area of wound coverage and offsetting the extent of contraction observed compared to FTSGs.

If a freehand STSG is planned, a no. 10 blade is used to superficially score the area of skin to be excised while the skin is held taut. The blade is then placed nearly parallel to the skin, and starting at the scored edge the scalpel is used to create a surgical plane through the dermis while the graft is gently lifted from the wound edge with toothed forceps.

If the Weck blade, a razor-like knife, is used, the skin is held taut, and a sawing motion is employed with the blade placed almost parallel to the skin with forward and downward pressure applied, similar to a shave biopsy. If an electric dermatome is used, desired graft thickness is first adjusted on the dermatome. The operating surgeon then applies downward and forward pressure with the advancing dermatome while the skin is held taut and the skin graft is delivered from the dermatome with toothed forceps. Mineral oil can be applied to the surface of the skin to minimize friction and improve the dermatome blade's ability to glide smoothly and uniformly across the skin surface.

If a meshing device is used, the desired expansion grid is selected and inserted into the device. The graft is then placed flat into the meshing device and advanced through with a lever. The harvested graft is transferred to a basin containing sterile saline. After careful hemostasis is achieved at the recipient site, the STSG is placed on the wound, trimmed with iris scissors to fit the defect, and sutured into place in a similar manner as with FTSGs. STSGs are typically quite large, and although simple interrupted sutures can be placed around the entire periphery of the graft site, suturing efficiency can be optimized by first positioning a number of interrupted anchoring sutures evenly around the edge of the graft and then placing a running suture around the entire graft perimeter. If the STSG was not meshed, a no. 10 or no. 15 blade can be used to create uniform linear fenestrations within the STSG. This allows serosanguinous fluid from the wound bed to drain into the dressing rather than pool under the graft where it will interfere with the graft's ability to contact the wound bed. The donor site should be dressed with a moist occlusive dressing consisting of petrolatum, an absorbent layer, and surgical tape. The pinpoint bleeding present at the donor site will abate with a pressure dressing alone, and additional hemostasis with aluminum chloride or electrocautery is usually not required.

FREE CARTILAGE GRAFTS

Cartilage grafts are used to maintain the protuberant structures of the nose and ears. Cartilage grafts are composed of cartilage with adherent perichondrium, and can be grafted alone or attached to the overlying skin as a composite graft. Cartilage grafted alone allows for more flexibility in donor

site selection. The cartilage support structure can be harvested separately from the skin that is selected to cover the defect from a local flap or skin graft. Cartilage grafts are commonly used in the repair of nasal defects, especially of the nasal ala to prevent alar notching or collapse, and to preserve function of the nasal valve. Cartilage grafts are also commonly used on the helical rim when helical cartilage is removed during tumor extirpation to preserve the natural curve of the helix and prevent aesthetically displeasing notching of the ear. They provide an invaluable tool to prevent poor functional and cosmetic outcomes that result from the forces of contraction during wound healing at anatomic free margins (Fig. 28-8).



A



B

Figure 28-8. (A) A full-thickness defect of the nasal ala is repaired with a free cartilage graft from the conchal bowl to recreate the natural curvature of the ala. The cartilage graft is harvested with a postauricular approach. An FTSG is harvested from the postauricular skin to cover the surgical defect and cartilage graft. Alar form and function are preserved at suture removal and excellent cosmesis is achieved at 6-week follow-up. The cartilage graft donor site heals well without aesthetic penalty. (B) A full-thickness defect of the nasal ala is repaired with a free cartilage graft from the antihelix to preserve alar contour. The overlying FTSG is harvested from the skin of the antihelix. Favorable contour and color match are achieved at long-term follow-up.

Graft selection

Antihelical and conchal bowl cartilages are both commonly used for repairs in dermatologic surgery. Conchal bowl cartilage is typically used when a larger piece of cartilage is required for repair of the nasal ala, columella, septal cartilage, or the crura of the lower nasal cartilage.³⁰ Although crural cartilage is an option for cartilage and soft tissue reconstruction, cartilage of the antihelix is usually sufficient in dermatologic surgery.

The cartilage of the antihelix is more elastic, less brittle, and has a greater innate curve than that of the concha, which generally makes it a more favorable option when a cartilage graft is required along an anatomic structure with natural curvature such as the helical rim or nasal ala.³¹ The antihelix is also easily accessible, and once the cartilage strip is harvested, the tension-free donor site can be closed primarily leaving a resulting scar that is almost imperceptible. Although typically cartilage grafts are covered with either a local flap or an FTSG, a cartilage alar batten graft alone may be sufficient in select patients for alar reconstruction with acceptable functional and aesthetic outcomes.³²

Technique

The cartilage graft donor site is first scrubbed with antiseptic and then anesthetized. The skin can be incised without a skin excision if a small cartilage graft is to be taken. A single incision with skin hook retraction on the wound edges can allow for adequate dissection of the overlying skin and visualization of the cartilage to be harvested. If a larger cartilage graft is planned, an ellipse of skin over the cartilage graft can first be removed to help visualize the underlying cartilage. The surgical defect is measured, and the cartilage graft is oversized by 10% to 15% relative to the size of the

cartilage strut required for structural support in order to have adequate length to tuck the cartilage graft edges into the recipient site.⁷

The cartilage graft is harvested using a no. 15 blade and is incised through the anterior perichondrium, through the cartilage, and then through the posterior perichondrium, with care taken not to incise through the postauricular skin. The graft is gently lifted using forceps, with care taken not to traumatize the delicate tissue. The cartilage graft can also be separated from the surrounding cartilage using iris or Castroviejo scissors. Thorough hemostasis is achieved at the recipient site. Small pockets are then created under the edges of the recipient skin using blunt dissection with surgical scissors or hemostats to create a space where the graft will be placed to interlock with the wound bed.³³

The graft is inserted into the wound bed, and a 5-0 absorbable lassoing suture is placed around the cartilage graft and through the wound bed to anchor the graft in place. If it is not possible to create pockets in the recipient site for the insertion of the edges of the cartilage graft, the edges of the graft can be sutured to the periphery of the wound bed with absorbable sutures. The freestanding cartilage graft is most often covered with an FTSG, transposition flap, or interpolation flap. The cartilage graft may also be left to heal by second intention with or without delayed grafting. The patient should be counseled that the cartilage graft donor site is likely to be more painful than the recipient site postoperatively due to chondritis of the donor auricular cartilage. Although no formal recommendations exist for antibiotic prophylaxis after cartilage graft placement, many suggest a fluoroquinolone antibiotic to minimize the risk of infection and subsequent graft failure.

COMPOSITE GRAFTS

Composite grafts contain cartilage, perichondrium, and overlying skin, and are thus the most metabolically demanding grafts. The metabolic demands of composite grafts limit their use to small, deep defects where cartilage and skin replacement is required, such as the marginal tissue of the alar rim (Fig. 28-9).



Figure 28-9. A full-thickness defect of the nasal ala is repaired with a composite graft from the crus of the helix.

Graft selection

When a partial or full-thickness alar rim or soft triangle defect ≤ 1.5 cm in diameter is present, a composite graft composed of skin and cartilage from the crus of the helix is a viable repair option.^{34,35}

Technique

The recipient wound bed edges are trimmed for a smooth semicircular contour. The donor site is scrubbed with antiseptic and anesthetized. A foil template from suture material provides a suitable three-dimensional material to be drawn and trimmed to the exact size and shape of the surgical defect, erring on the side of oversizing rather than undersizing to account for graft

contraction. As with free cartilage grafts, the cartilage portion of the graft may be oversized to fit into grooves created at the periphery of the recipient wound bed. Using the foil template, the donor site on the crus of the ear is traced with a surgical marking pen. A no. 15 scalpel is used to excise the composite graft containing skin, perichondrium, and cartilage, and the graft is briefly placed in a basin of sterile saline. Hemostasis is achieved at the graft recipient site, and the graft is inset into the surgical defect. If the cartilage is oversized for deliberate interlocking into the wound bed, pockets on each side of the recipient are first created with blunt dissection in the same manner as with the freestanding cartilage graft. To achieve a perfect fit, any excess skin or cartilage tissue from the composite graft that does not fit into the defect is trimmed with iris scissors. If a full-thickness alar defect is present, simple interrupted sutures are first placed on the mucosal side of the graft to secure it into place. Then, simple interrupted sutures are placed around the periphery of the skin graft on the epidermal surface. The graft donor site is left to heal by second intention or is repaired with a transposition flap from the immediate postauricular skin.³⁵ As with free cartilage grafts, patients may be treated with fluoroquinolone antibiotics after composite graft repair.

POSTOPERATIVE CARE

Patient education regarding the expected postoperative course and proper postoperative care is imperative for optimal surgical outcomes. The patient should be counseled about normal physiologic color changes seen in a graft during the immediate postoperative period. The graft will initially appear blanched and white. As imbibition begins to take place in the days following surgery, the graft will become edematous and violaceous. As inosculation and neovascularization are initiated and established around 1 week postoperatively, the graft will appear more pink in color. In the months following surgery, the edema of the graft will dissipate, and the color of the graft will return to the initial color of the donor skin.

The most important pearl in the immediate postoperative care of skin grafts is the avoidance of any shearing forces which will disrupt the inosculation and neovascularization of the immature graft and significantly increase the risk of necrosis. The use of bolster dressings has been

advocated to decrease shearing forces and it is some dermatologic surgeons' preference to routinely employ these. However, the use of bolster dressings has not been definitively demonstrated to increase the chances of graft survival.^{17,18,26} Table 28-2 is a list of pearls regarding the use of grafts and Table 28-3 is a list of pitfalls.

Table 28-2. Pearls

When harvesting from the preauricular region, take care not to transplant terminal hair follicles to a nonhair-bearing area.
Widely undermine the FTSG recipient site to minimize the risk of a pincushion deformity.
For skin grafts extending over the alar crease, a bolster suture can be placed in a linear fashion where the alar crease should naturally occur to improve nasal contour.
Delayed skin grafting over areas of exposed bone or cartilage can be used to improve chances of graft survival.
Grafts designed to cover Mohs defects can be harvested at a 45-degree angle to match the angle of the bevel used during the Mohs procedure.
Meticulous suturing techniques to maximize contact of the skin graft with the wound bed should be employed.
A graft with superficial necrosis is not necessarily doomed; careful wound care and watchful waiting can still result in a satisfactory final outcome.
The antihelix is an excellent cartilage graft donor site with minimal cosmetic or functional penalty.
Composite grafts are ideal for small, deep wounds that involve a skin and cartilage defect.

Table 28-3. Pitfalls

Shearing forces are the primary adversaries of graft success.

Failure to place fenestrations within an STSG can increase the chance of serosanguinous fluid pooling and graft necrosis.

Inadequate hemostasis may result in hematoma and decrease the rate of graft survival.

The use of an FTSG for a wound >5 cm or a wound with a tenuous blood supply is not recommended due to risk of graft necrosis.

Even perfect graft selection and surgical technique cannot prevent graft failure in patients with heavy tobacco use.

Lack of careful graft selection for ideal color match is likely to result in suboptimal aesthetic outcomes.

A graft that is undersized is much more difficult to alter for ideal fit than a graft that is oversized.

Wound infection increases the likelihood of graft failure and graft contraction. Prompt assessment and appropriate treatment of wound infections are crucial.

Lack of patience in awaiting graft maturity before the 3-month postoperative time point can result in unnecessary stress and scar refinement procedures. Regular follow-up and reassurance are key.

If a bolster is not placed, the pressure bandage placed postoperatively should be left for 24 to 48 hours. After removal, the patient is instructed to gently wash the area with a mild soap and water once or twice daily. The graft is then covered with petrolatum ointment and a sterile bandage. This is repeated until suture removal, which is performed at 5 to 7 days for grafts on the face, 10 to 12 days for grafts on the scalp, and 12 to 14 days for grafts on the trunk and extremities. If a dry tie-on bolster dressing is placed, most dermatologic surgeons advocate keeping the surgical site dry for 1 week postoperatively until the bolster is removed. If petrolatum-soaked gauze for the bolster dressing is utilized, the patient is generally recommended to gently wash around the bolster dressing daily and apply additional

petrolatum ointment on and around the dressing to preserve the moist environment of the surgical site.

If an eschar is present at suture removal, this does not necessarily indicate complete graft necrosis. It is not uncommon to observe superficial slough that can be gently debrided. Grafts that are thicker or on poorly vascularized wound beds are more prone to this outcome. With continued daily cleansing and petrolatum ointment application, many of these grafts will re-epithelialize with a satisfactory aesthetic result. If complete necrosis does occur, the necrotic graft should be gently debrided, and the wound allowed to heal by second intention before any additional revision surgeries or procedures are planned.

The appearance of grafts tends to significantly improve in the 3 to 4 months following surgery. Most patients will require close follow-up and reassurance during the postoperative period. It is recommended to wait at least 3 months before performing scar revision or refinement procedures.

CONCLUSIONS

Skin grafts are most often utilized when primary closure, flap repair, and second intention healing are not feasible or inappropriate for the repair of a surgical defect. Although the cosmesis of skin graft closures can be inferior to that of wounds closed primarily or by flap closure, skin grafts provide a straightforward one-step procedure for anatomic areas with minimal skin laxity. Excellent aesthetic results and functional outcomes are possible with appropriate graft selection, meticulous surgical technique, and patient compliance. A thorough knowledge of the indications, selection, technique, complications, and postoperative care of FTSGs, STSGs, cartilage grafts, and composite grafts is essential for the practicing dermatologic surgeon.

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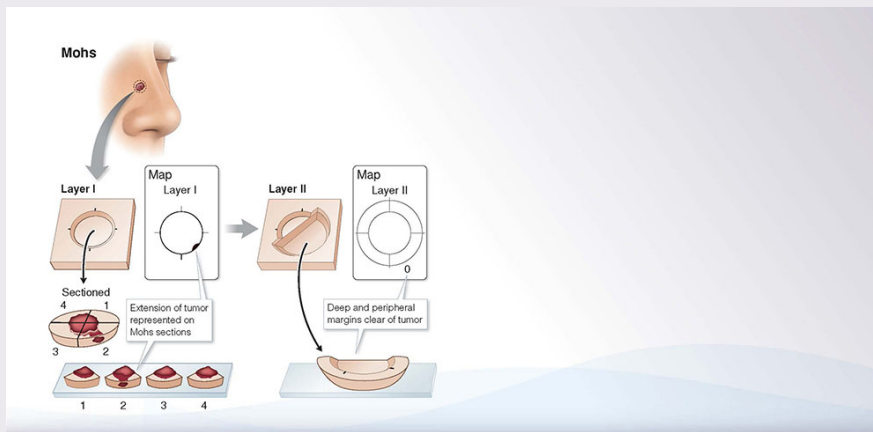
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CHAPTER 29 Mohs Micrographic Surgery

Ramona Behshad



SUMMARY

- Utilizing horizontal sections permits the full peripheral and deep margin to be assessed by the Mohs surgeon.
- Mohs surgeons act as both surgeon and pathologist.
- Mohs has the highest cure rate for nonmelanoma skin cancers, and is appropriate for most nonmelanoma skin cancers of the head and neck.
- Appropriate use criteria were jointly developed by the AAD, ACMS, ASDS, and ASMS to delineate which tumors are appropriately treated with this technique.

Beginner Tips



- Meticulous attention to detail is required for all steps of Mohs surgery.
- An experienced technician is vital in the preparation of high-quality slides for evaluation.
- Overlap between stages is critical to success.
- Technical errors impacting slide quality are the most common cause of recurrence after Mohs surgery.

Expert Tips



- Beware of aggressive curettage.
- Excessive facing of the block is associated with both false-positive and false-negative results.
- Patients with a history of CLL or organ transplant have a significantly higher rate of prominent inflammatory foci, increasing the challenge of slide interpretation.

Don't Forget!



- When removing cartilage, including some noncartilaginous tissue at one edge will prevent the cartilage from floating off during processing.
- Keep in mind the risk of cerebral air emboli with exposed calvarium.
- Always overlap areas of positive tumor.

Pitfalls and Cautions



- Sectioning tissue may be associated with an increased risk of error; therefore, if appropriate, tumors may be embedded as a single unit.
- Fat should be frozen to a lower temperature to encourage appropriate cutting; this can be accomplished by using a cryogen.

Patient Education Points



- Mohs provides the highest cure rates of any technique for the treatment of skin cancer.
- Patients should come prepared for a full day at the office and bring a book, electronic device, and snacks if desired.

- For patients that are squeamish or anxious, Mohs may not represent the best option for treatment, or perioperative anxiolytics could be considered.

Billing Pearls



- Coding for Mohs is relatively straightforward, with the 17311–2 series and 17313–4 series used for tumors of the head/neck/hands/feet/genitalia and all other areas, respectively.
- The add-on codes (17312 or 17314) may never be used in isolation.
- If Mohs surgery is continued on a subsequent day, coding begins anew.
- Mohs surgery codes may never be utilized if the same physician does not act as surgeon and pathologist.
- Biopsies or frozen sections performed on the day of surgery should be billed with the appropriate modifier. Remember to document the need for the biopsy and frozen section interpretation and outline that it is distinct from the Mohs procedure.

CHAPTER 29 Mohs Micrographic Surgery

INTRODUCTION

Mohs micrographic surgery (MMS) is a specialized surgical technique that achieves the highest cure rates of any skin cancer treatment, making it the treatment of choice for most skin cancers on the head and neck as well as for recurrent or histologically aggressive lesions. It differs from other techniques in that microscopic margin examination occurs using an intraoperative stepwise approach, thereby eliminating the need to estimate tumor extent. Unlike standard tissue processing, Mohs surgery uses horizontal frozen sections that capture 100% of the peripheral and deep surgical margin in one plane. Residual tumor, if present, is mapped and excised selectively until the entire tumor is removed.

Incorporating meticulous tumor mapping into the removal process requires the surgeon to act in two distinct capacities: as surgeon and pathologist. This further lowers the potential for human error in a situation where tissue orientation is of critical importance. It is well suited for contiguous tumors, most commonly basal cell carcinoma (BCC) and squamous cell carcinoma (SCC), although it is being used more frequently for rarer cutaneous tumors and for melanocytic malignancies (see [Chapter 31](#)).

Many studies have demonstrated the efficacy of MMS for the treatment of skin cancer.¹⁻⁴ MMS has a 5-year cure rate of 98% to 99% for previously untreated BCC^{1,3,4} and 94% to 97% for SCC.^{1,2,5} For recurrent BCC, the 5-year recurrence rate remained lower after treatment with MMS (5.6%) than

after surgical excision (17.4%), electrodessication and curettage (40%), or radiation therapy (9.8%).³

Since Mohs surgery allows removal of the cancer with minimal waste and damage to normal surrounding skin, long-term functional and cosmetic results may be optimized. Still, with each procedural step, there is the opportunity for small errors by the Mohs surgeon and lab technician that can be additive, and therefore, strict attention to detail is of critical importance.

INDICATIONS

Mohs surgery is not necessary for all skin cancers. The indications for Mohs surgery have been recently defined based on pathologic tumor characteristics, tumor size, clinical tumor characteristics, and certain host characteristics.⁶ Scoring is assigned as appropriate (7 to 9), uncertain (4 to 6), or inappropriate (1 to 3) for Mohs surgery based on factors detailed below and in [Table 29-1](#).

Table 29-1. Scoring for Mohs Surgery

	Appropriate	Uncertain	Inappropriate
Area H			
BCC	Primary or recurrent: aggressive, nodular, superficial		
SCC	Primary or recurrent: aggressive, nonaggressive, verrucous, KA-type SCC, SCC in situ/Bowen		Primary or recurrent: AK with focal SCC in situ
Area M			
BCC	Primary or recurrent: aggressive, nodular, superficial (IC) Primary: superficial >0.6 cm	Primary: superficial <0.5 cm	
SCC	Primary or recurrent: aggressive, nonaggressive, KA-type SCC, SCC in situ/Bowen		Primary or recurrent: AK with focal SCC in situ
Area L			
BCC	Recurrent: aggressive, nodular Primary: aggressive >0.6 cm, nodular >2 cm (>1.1 cm in IC)	Primary: aggressive <0.5 cm, nodular 1.1–2.0 cm (0.6–1 cm in IC), superficial (IC) >1.1 cm	Recurrent: superficial Primary: nodular <1 cm (<0.5 cm in IC), superficial of any size (<1 cm in IC)
SCC	Primary or recurrent: aggressive Recurrent: KA-type SCC, nonaggressive Primary >2 cm Nonaggressive (IC), SCC in situ/Bowen Primary >1.1 cm Nonaggressive (IC), KA-type SCC, SCC in situ/Bowen (IC), KA-type SCC (IC) >0.6 cm	Recurrent: SCC in situ/Bowen Primary 1.1–2.0 cm Nonaggressive, SCC in situ/Bowen Primary <1 cm Nonaggressive (IC) Primary 0.6–1 cm SCC in situ/Bowen (IC) Primary <0.5 cm KA-type SCC (IC)	Primary or recurrent: AK with focal SCC in situ Primary <1 cm Nonaggressive, KA-type SCC, SCC in situ/Bowen Primary <0.5 cm SCC in situ/Bowen (IC)

Listed indications are for both healthy and IC patients, and tumors of any size unless otherwise specified. Nonaggressive SCC indicates SCCs without aggressive features, <2 cm depth without other defining features, Clark level <3.

AK, actinic keratosis; BCC, basal cell carcinoma; KA, keratoacanthoma; IC immunocompromised; SCC, squamous cell carcinoma.

Area H: Mask area of the face (central face, eyelids, eyebrows, nose, lips, chin, ear, periauricular skin, temple), genitalia, hands, feet, nail units, ankles, and nipple/areola.

Area M: Cheeks, forehead, scalp, neck, jawline, pretibial surface.

Area L: Trunk and extremities (excluding pretibial legs, hands, feet nail units, and ankles).

Data from Ad Hoc Task Force¹, Connolly SM, Baker DR, et al: AAD/ACMS/ASDSA/ASMS 2012 appropriate use criteria for Mohs micrographic surgery: a report of the American Academy of Dermatology, American College of Mohs Surgery, American Society for Dermatologic Surgery Association, and the American Society for Mohs Surgery, *J Am Acad Dermatol*. 2012 Oct;67(4):531–550.

Location

Tumor location can be subdivided into three areas: high risk, medium risk, and low risk (Fig. 29-1). High-risk areas (H) include the “mask areas” of the face (eyelids, eyebrows, nose, lips, chin, ear, periauricular skin, and temples), genitalia, hands, feet, nail units, ankles, and nipples or areola. Medium-risk areas (M) include the head and neck areas (cheeks, forehead, scalp, neck, and jawline) and pretibial surface. Low-risk areas (L) include the trunk and extremities, excluding the areas included in areas H and M. Under the appropriate-use criteria, all SCC and BCC (except primary actinic keratosis with focal SCC in situ) are appropriately treated by Mohs if located in the H area. All skin cancers in the M area are considered appropriate, except for small superficial BCCs equal to or less than 5 mm in size and primary actinic keratoses with focal SCC in situ. MMS is typically reserved for larger, recurrent, or more aggressive tumors on L areas.

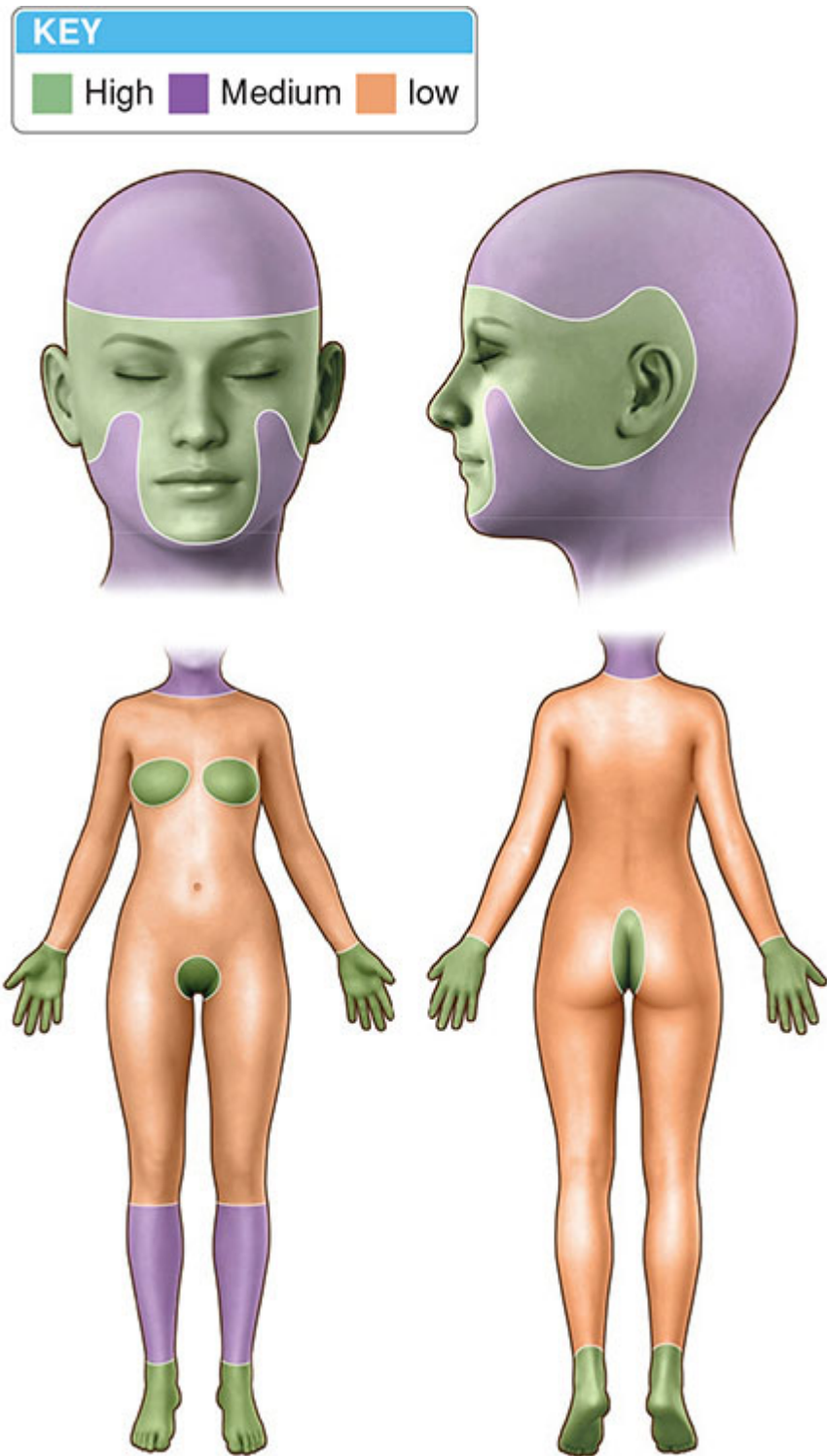


Figure 29-1. Tumor location can be subdivided into three areas: high-risk (**green**), medium-risk (**purple**), and low-risk (**orange**) areas. High-risk areas (H) include the “mask areas” of the face (eyelids, eyebrows, nose, lips, chin, ear, periauricular skin, and temples), genitalia, hands, feet, nail units, ankles, and nipples or areola. Medium-risk areas (M) include the head and neck areas (cheeks,

forehead, scalp, neck, and jawline) and pretibial surface. Low-risk areas (L) include the trunk and extremities, excluding the areas included in areas H and M.

Patient characteristics

Certain patients are at a greater risk for aggressive and recurrent tumors. Tumors in immunocompromised patients (HIV, organ transplantation, hematologic malignancy, or pharmacologic immunosuppression) have double the risk of metastatic disease compared with immunocompetent patients (13% vs. 5%).⁷ Patients with chronic lymphocytic leukemia also have higher rates of recurrence when compared with immunocompetent controls,⁸ and patients with genetic syndromes that make them more susceptible to skin cancers, such as xeroderma pigmentosum, basal cell nevus syndrome, and Lynch syndrome, are more likely to have aggressive tumors. These patients are all appropriate candidates for Mohs surgery even when tumor characteristics demonstrate lower-risk lesions.

Tumor characteristics

The preoperative biopsy should be reviewed for signs of aggressive histologic features, as such BCCs and SCCs are more likely to locally recur and metastasize. Morpheaform/fibrosing/sclerosing, infiltrating, metatypical/keratotic, and micronodular BCCs contain small nests of malignant cells and have a high propensity for recurrence.^{1,9} Sclerosing, basosquamous, poorly differentiated or undifferentiated, infiltrating, keratoacanthoma (central facial), clear cell, sarcomatoid, Breslow depth 2 mm or more, Clark level 4 or greater, pagetoid, single cell, lymphoepithelial, and small cell tumors similarly have an increased risk of recurrence and metastasis.^{7,10,11}

According to the appropriate-use criteria, any aggressive histologic feature for SCC makes it appropriate for MMS, regardless of all other characteristics. This guideline is similar for BCCs, with the exception of aggressive BCCs on location L that measure <5 mm in diameter. For all subtypes of BCC and SCC, perivascular and perineural involvement are indications for MMS. The presence of significant pain or paresthesia should alert the physician to the possibility of perineural invasion,¹² as this finding

is not always seen on initial biopsy due to sampling error. MMS is also appropriate for all tumors occurring within radiated skin, traumatic scars, areas of osteomyelitis, patients with genetic syndromes, and areas of chronic inflammation. Recurrence of a previously treated BCC or SCC is also a strong indication for using MMS.^{10,13}

PREOPERATIVE EVALUATION FOR MOHS MICROGRAPHIC SURGERY

The initial consultation forms the basis for all future interactions between the physician and the patient. The indications and alternatives to Mohs surgery, including standard excision or no treatment, must be discussed with the patient so that he or she may make an informed decision to proceed. As a relatively low-risk procedure, Mohs surgery can be safely performed in elderly patients with stable comorbid conditions.¹⁴

Once MMS has been deemed appropriate for a given tumor and patient, a history and focused physical examination should be performed. When obtaining the patient's past medical history, several medical and psychological issues are taken into consideration. These include allergies, medications (including anticoagulants and immunosuppressants), previous infections and hospitalizations, artificial implants, and genetic cancer syndromes. Discussion with the patient about cessation of tobacco use during the perioperative period should also occur. Cigarette smokers should be advised to decrease smoking to the greatest degree possible for 1 week before and 1 week after surgery to lessen the risk of poor wound healing.

Hemostasis

The presence of any implanted cardiac pacemakers and defibrillators should be noted, and an appropriate method of electrosurgery selected (see [Chapter 16](#)). For patients with pacemakers and implantable cardioverter defibrillators (ICDs), it may be safest to utilize electrocoagulation with bipolar forceps or a hand-held heat cautery device.^{15,16} When using standard monopolar electrosurgical devices, frequently practiced precautions include applying short bursts of energy (<5 seconds), using minimal power, and

avoiding use of electrosurgery around the implanted device.¹⁷ Epinephrine, which is commonly added to local anesthetics, should be avoided in epinephrine-sensitive patients.

Anticoagulants

Patients taking purely elective prophylactic anticoagulants and herbal supplements can be counseled to stop 1 to 2 weeks prior to surgery. Patients should not drink alcohol 24 hours prior to the procedure or 48 hours after the procedure to reduce the risk of bleeding. In patients taking medically necessary anticoagulants, however, the risk associated with postoperative bleeding is significantly lower than the risk of thromboembolic events that may occur if this anticoagulation is ceased.¹⁸ Therefore, most dermatologic surgeons allow patients to continue anticoagulants and antiplatelet medications in the perioperative period. In patients taking coumadin, an INR may be reviewed to ensure it is within the therapeutic window (and preferably three or less).

Prophylactic medications

Indications for antibiotic prophylaxis should be reviewed and prescribed for certain patients at risk for infective endocarditis, hematogenous joint infections, and/or surgical site infections. While Mohs surgery rarely falls into any of the qualifying categories for hematogenous joint or heart valve infections, prophylactic antibiotics are recommended when the surgical site is considered high risk for surgical infection. Sites and locations at high risk for surgical infection include the lower extremities, groin, wedge resection of the lip or ear, skin flaps on the nose, skin grafts, or areas of extensive inflammatory skin disease.¹⁹ For most procedures, a first-generation cephalosporin or dicloxacillin is adequate for wound infection prophylaxis (Table 29-2). Antivirals may also be considered if surgery will occur on anatomical sites of prior HSV outbreaks, such as the cutaneous or vermilion lip. Antianxiety medications can be prescribed, but cannot be taken until the patient has consented to the procedure.

Table 29-2. Prophylactic Medications for Mohs Surgery

Site	Antibiotic	Dose
Skin	Cephalexin	2 g PO
	Dicloxacillin	2 g PO
	Clindamycin ^a	600 mg PO
	Azithromycin/clarithromycin ^a	500 mg PO
Oral lesions and Mucosa	Amoxicillin	2 g PO
	Clindamycin ^a	600 mg PO
	Azithromycin/clarithromycin ^a	500 mg PO

All doses are given 30–60 minutes preoperatively as a single dose, although an extended course of antibiotic treatment can be considered.

^aAlternative medication for penicillin-allergic patients.

Data from Wright TI, Baddour LM, Berbari EF, et al. Antibiotic prophylaxis in dermatologic surgery: advisory statement 2008, *J Am Acad Dermatol*. 2008 Sep;59(3):464–473.

Physical examination

The physical examination is focused on identifying the tumor location, which should be documented prior to surgery and confirmed with the patient. Confirming the biopsy site is a prerequisite to proceeding with Mohs surgery, although this can be difficult in patients with severe actinic damage, multiple scars, rosacea, and many seborrheic or actinic keratoses. Photographs, diagrams, tangential lighting, Wood's lamp, and magnification are helpful,²⁰ as patients presenting for dermatologic surgery have been shown to be incorrect 16.6% to 31.4% of the time when attempting to identify their surgical site.²¹ If these measures are unavailable or unsuccessful, a protocol should be in place. One published protocol involves both physician and patient participation in biopsy-site identification at consultation. If the biopsy site was not identifiable, then further consultation was undertaken with the patient's referring provider and/or family. Frozen biopsies were employed if necessary to identify tumor sites on the day the patient presented for surgery. If the biopsy site still could not be identified, then frozen biopsy specimens were sent for permanent sections and the patient was observed at 3-month

intervals. Over a 6-year period, there were no cases of wrong-site surgery in 7983 MMSs performed; surgery was, however, occasionally deferred because the correct biopsy site could not be identified.²²

On the other end of the spectrum, patients with extremely large or deeply invasive tumors, especially with motor nerve findings or lymphadenopathy, may require a multidisciplinary approach and preoperative imaging or consultation. Ophthalmology, otolaryngology, radiology, oncology, surgical oncology, neurosurgery, and plastic surgery may all at times be consulted by the Mohs surgeon in the perioperative period.

TECHNIQUE

The fundamental technique was pioneered by Frederic Mohs in the 1930s, and his landmark article on 440 patients treated with chemosurgery was published in 1941.²³ At that time, Mohs used zinc chloride paste for in vivo fixation prior to surgical removal. Dr. Mohs applied zinc chloride paste to the cancerous skin to fix the tissue prior to excision. The following day, the tissue was excised and examined under the microscope. The process was repeated daily until the tumor margins were clear.

The original in vivo chemosurgical approach transitioned to the fresh frozen tissue technique beginning in 1953, an innovation pioneered by Dr. Mohs for eyelid cancers to prevent ocular damage by the zinc chloride paste. Subsequently, the technique was popularized and described in detail by Tromovich and Stegman in 1974.²⁴ The fresh frozen technique obviated the need for escharotic zinc chloride paste, allowed complete tumor clearance in 1 day and immediate surgical reconstruction.

The Mohs procedure is considered a *clean* procedure rather than a *sterile* procedure. Once the biopsy site is identified with confidence, and patient consent is obtained, the area is typically prepped with chlorhexidine or Betadine and then draped. Local anesthesia is first infiltrated. Lidocaine 1% to 2% with epinephrine 1:100,000 is used most commonly, although nerve blocks and long-lasting anesthetic such as bupivacaine may be helpful to prolong anesthesia (see [Chapter 12](#)).

With Mohs surgery, the tumor is removed in a saucer-shaped section and divided into pieces for processing ([Fig. 29-2](#)). Evaluation of all excised margins reveals skin cancer present at one edge. The area is subsequently

mapped and excised on layer II. With the Mohs method, no tumor is missed. In contrast, bread-loafing of the elliptical excision specimen for histologic examination could miss tumor extending to the margin because only a small portion of the margin is examined.

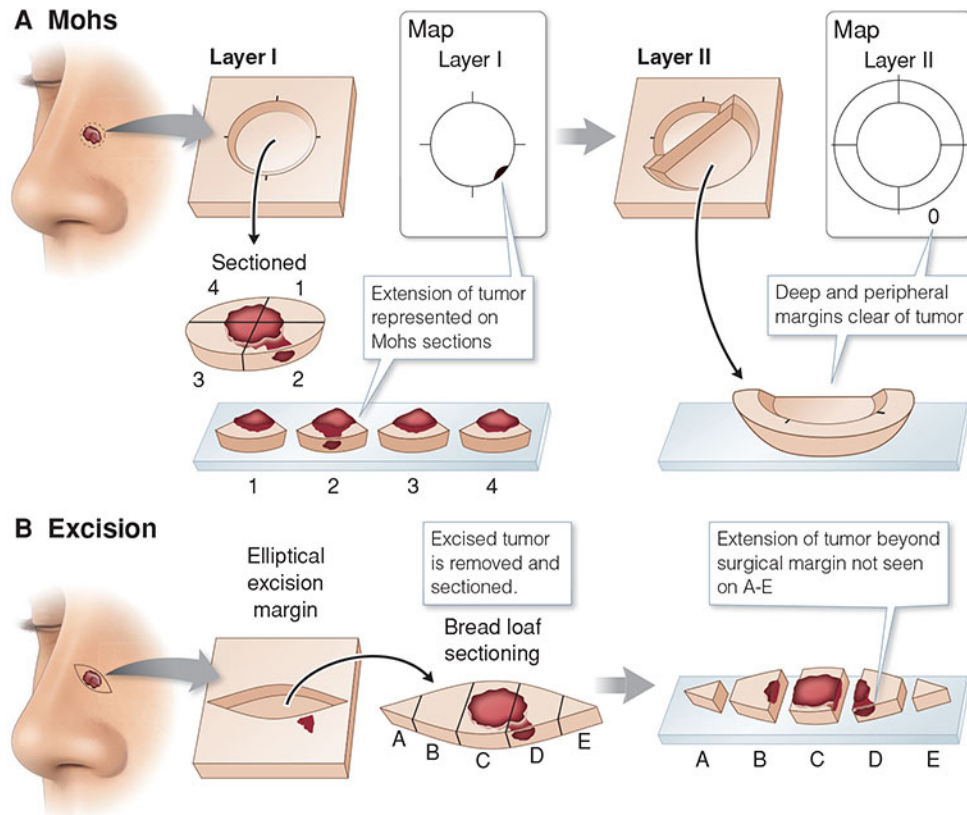


Figure 29-2. With Mohs surgery, the tumor is removed in a saucer-shaped section and divided into pieces for processing. Evaluation of all excised margins reveals skin cancer present at one edge. The area is subsequently mapped and excised on layer II. With the Mohs method of tissue processing, no tumor is missed. In contrast, bread-loafing of the elliptical excision specimen for histologic examination could potentially miss tumor extending to the margin since only a small portion of the margin is examined.

Appropriate instruments, organization, and setup are essential for optimizing outcomes (Fig. 29-3). The fresh tissue technique of MMS has been simplified into debulking the tumor followed by excising and orienting; sectioning and inking; flattening, embedding, and freezing; cutting and staining; and mapping the tissue. It takes great skill to take a Mohs layer that can be processed perfectly by the lab, and Mohs surgeons should be aware of the technical challenges inherent in each step of specimen processing. The success of the procedure is tied to the precise application of each step of the

technique and the expertise of the individuals performing them. Technical errors impact slide quality, and represent the most common cause of local recurrence after MMS.²⁵

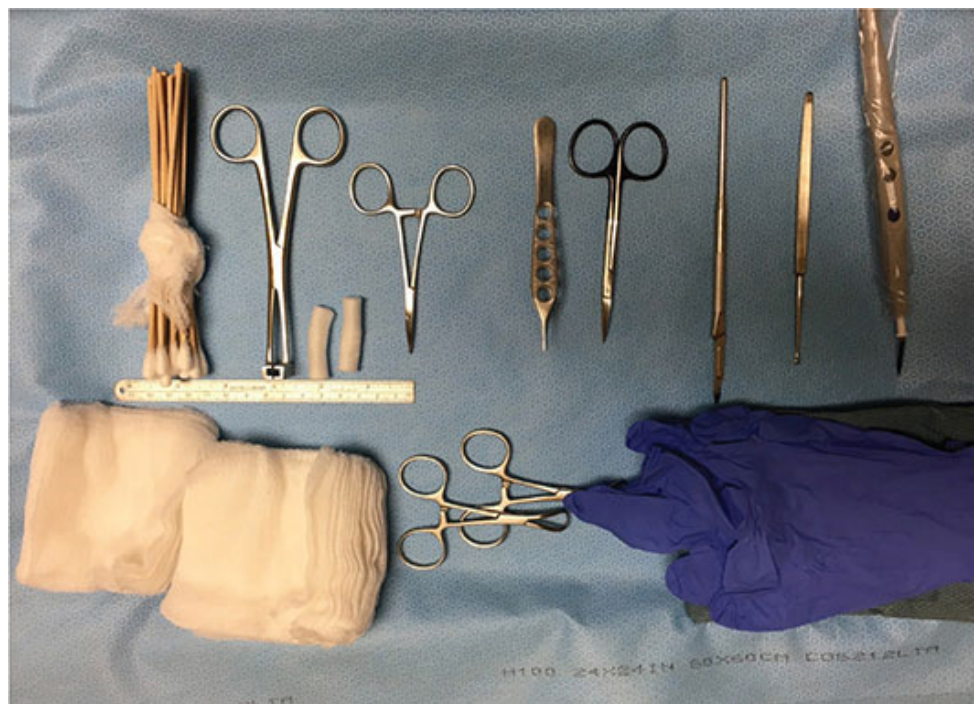


Figure 29-3. Standard instruments for Mohs surgery. Clockwise from *top left* corner: cotton-tipped applicators, blade remover, dental rolls, curved hemostat, forcep, supercut scissors, scalpel with 15 blade, curette, electrocautery device, gloves overlying towels for draping, towel clamps, gauze, and a ruler.

Debulking

Many surgeons curette the lesion until visually normal skin is reached to help identify the tumor margins.^{26,27} To perform curettage, a curette is scraped over the tumor in different directions with moderate pressure, producing fragments of friable tumor that can be wiped away to reveal a clean wound base or to produce a vertically oriented slide of tumor pathology when a previous biopsy is unavailable or has not been done (Fig. 29-4). Curettage is helpful in debulking friable tumor prior to MMS, but it does not reliably delineate the entire extent of a tumor.^{27,28} Infection, crusting, hyperkeratosis, background seborrheic dermatitis, and actinic keratoses may exaggerate the tumor size, resulting in an overly large debulking layer.



Figure 29-4. Curettage prior to taking of first Mohs layer to debulk the tumor and clinically assess the gross tumor margins.

Since most MMS occurs after a diagnostic biopsy, there is frequently an area of eschar overlying the cancer site. Since it is of no clinical value and can interfere with the production of high-quality slides, the eschar should be removed by the surgeon or technician prior to processing the tissue.

Aggressive curettage is not advocated. Curettage may cause shearing forces on the remaining, adjacent epidermis that will be included in the Mohs layer, which may lead to epidermal separation that will appear as clefting at the dermal–epidermal junction or as epidermal loss. In addition, the technician may interpret torn epidermis as a purposeful nick, leading to inaccurate sectioning. In severely photodamaged skin, this can also result in overhanging pieces of epidermis at the edges that can lead to false positives if this free epidermis is embedded near the margin (Fig. 29-5). Floaters are also more common after curettage,²⁹ so care must be taken to wipe the debulked tissue prior to excising the layer (Fig. 29-6).

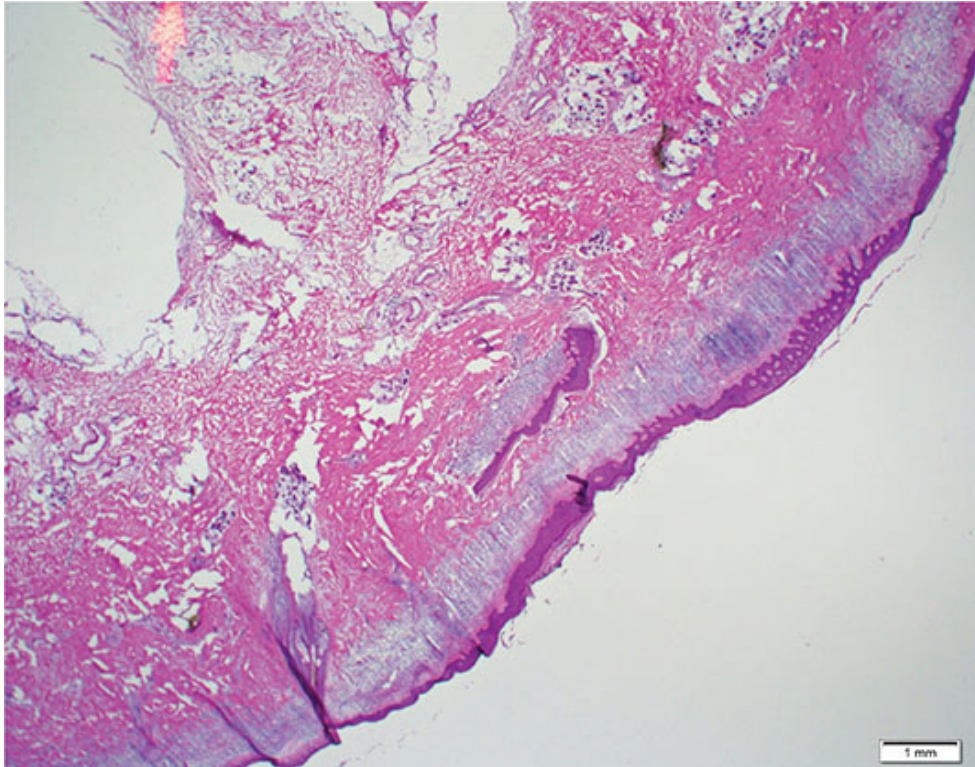


Figure 29-5. An artifact of aggressive curettage with overhanging epidermis implanted into the margin.



Figure 29-6. The curetted tumor is wiped away.

Excising tissue for optimal sectioning and orientation

The steps in Mohs excision are illustrated in [Figure 29-7](#). The Mohs surgeon must decide where to designate 12 o'clock on the excised specimen. Some practices always orient tissue toward an anatomic structure such as the vertex scalp or the ear lobule, while others orient 12 o'clock superiorly, medially, and/or posteriorly. The method is not as important as consistency. Thus, the Mohs surgeon always has a general idea of tissue orientation, even when the reference nick is not easily identifiable on the patient. Once this has been determined, the tumor is excised with a narrow clinical margin, including the deep plane, in a disk shape ([Fig. 29-7](#)). The margin varies from one to several millimeters depending on the size, location, and histology of the tumor. Before the skin is fully excised, several incisions (nicks) are made in the Mohs layer and in the adjacent skin for orientation, usually at 12-, 3-, 6-, and 9-o'clock positions although individual cases may require alterations ([Fig. 29-7](#)). The skin edges are beveled 30 to 45 degrees to allow for en face sectioning of the deep and peripheral margins simultaneously, with the exception of thin tissue such as eyelid and mucosa where little to no bevel is required ([Fig. 29-7](#)). After the tissue is completely removed, it is placed on a piece of gauze, filter paper, or a card ([Fig. 29-7H](#)). A map of the specimen is drawn, indicating the locations of the nicks that orient the tissue on the patient ([Fig. 29-8](#)). When specimens contain cartilage, bone, or subcutaneous tissue without any skin edge, this should be indicated on the map. Pressure and/or electrosurgery is used for hemostasis, and a dressing is applied to the surgical wound. The patient then waits for the tissue to be processed, which usually takes 30 to 60 minutes.

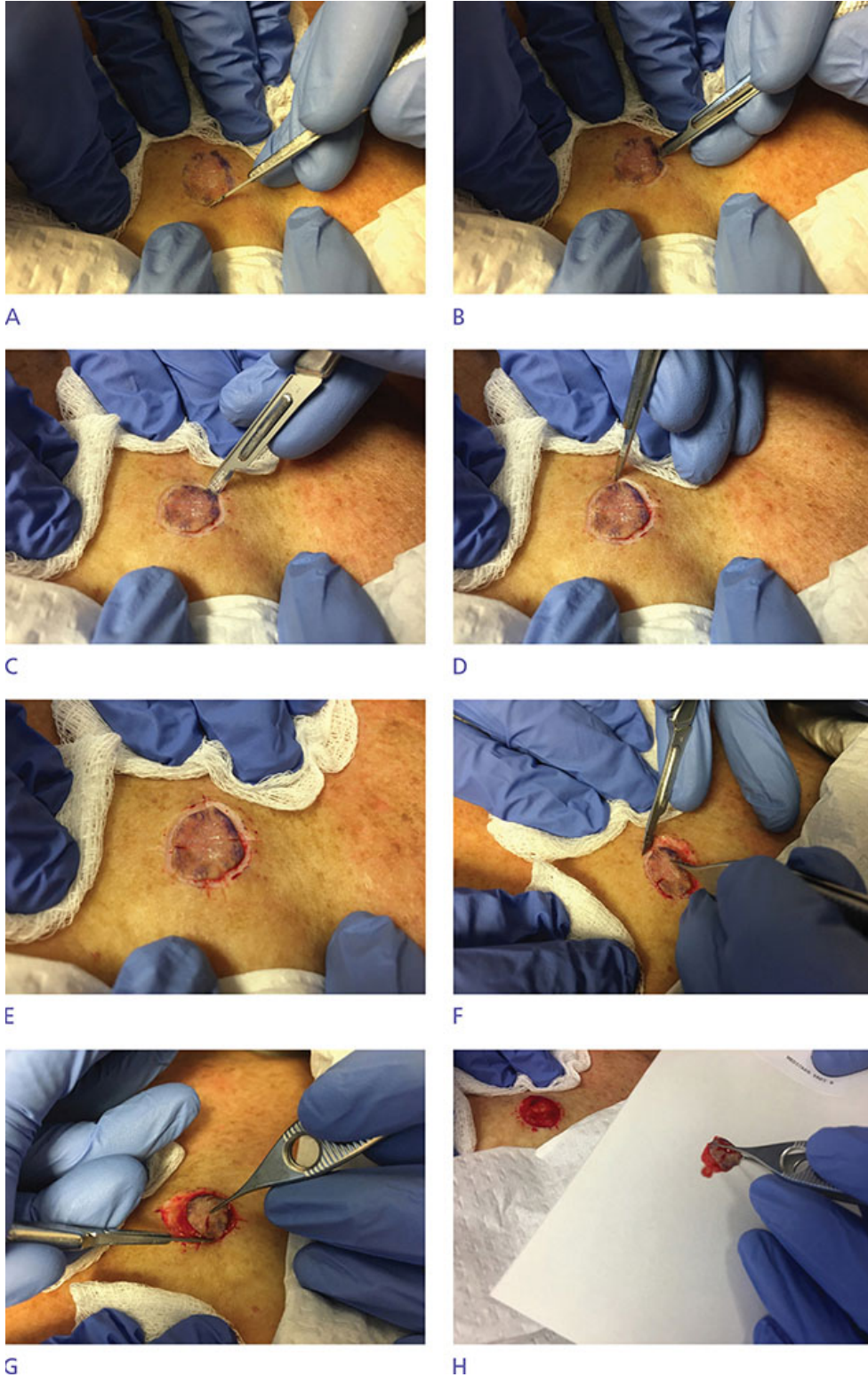


Figure 29-7. (A–C) Pie-shaped excision of the skin cancer with the scalpel blade at a 45-degree angle. (D–E) Hash marks are placed to orient the tissue. The specimen is cut with 12 o'clock as the superior orientation. The tissue is removed as one piece. The specimen should be cut from all edges

toward the center and not from one edge through to the other side. (H) The tissue is placed on filter paper for orientation to the patient and the card. In this case, the patient label indicates 12 o'clock.

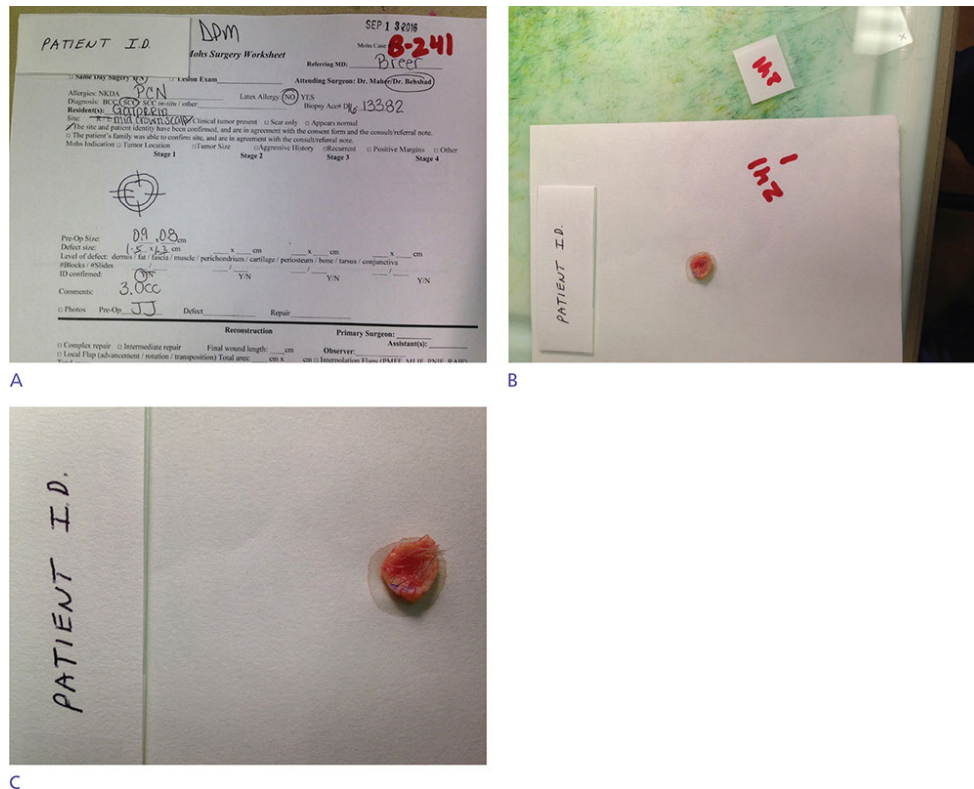


Figure 29-8. (A) The tissue is taken to the lab accompanied by the patient requisition. A comparable drawing is made of the tissue noting the marking hashes that orient the tissue on the patient. Stage one specimen with reference nicks at 12, 3, 6, and 9 o'clock. A *double circle* represents the areas that epidermis is included. A *single circle* or *line* represents a nonepithelial, surgically cut edge on the Mohs map. Others may represent this differently, although a standard annotation for epithelial edge is necessary. (B) A case number (in this case B-241 is assigned). (C) Here, by convention, the tissue is oriented on the filter paper so that 12 o'clock is toward the patient label.

The excised tissue specimen is carefully transferred to the lab, maintaining proper anatomic orientation. A dot or patient label in a designated corner of the transfer medium may be used to designate 12 o'clock. The tissue is logged, usually with the patient's information, such as name, site, and a Mohs case number. The technician should scan for reference marks that approximate the accompanying map. Any discrepancies must be resolved with the Mohs surgeon prior to processing the tissue.

The specimen should be cut from the lateral epidermal edges toward the center by using separate incisions with the blade, and not by using a single

incision from one edge continuously through to the other side. This ensures a uniform bevel and a uniform base.

When removing a recurrent skin cancer, the scar should ideally be removed to a plane deeper than the previous surgery, and the peripheral margin should be cut wider than the scar, although local anatomy may alter the depth of tissue taken. Clinical judgment will determine whether the entire scar, or only a portion of the scar, needs to be excised.

When excising cartilage, including some noncartilaginous tissue at one edge will help the technician prevent the cartilage from floating off the slides during processing.

When excising deep layers for fat or muscle, the surgeon should ideally take 4- to 5-mm-thick specimens to allow adequate tissue for processing and to prevent visible holes in the tissue after processing. Novice surgeons may wish to paint the entire base of the Mohs defect with a nonvital dye prior to taking a deep section; ensuring that no dyed tissue remains after taking the layer guarantees that the entire deep margin was removed.

Always assess whether cutaneous or sensory nerves are at risk, and take necessary precautionary measures. These include injection to exaggeratingly tumesce tissue prior to excision, provide upward traction, and of course obtaining appropriate informed consent explaining the risk of nerve injury.

Sectioning and inking

Some tumors may be sectioned into two or more pieces prior to processing; however, analysis of a single specimen with four evenly placed marks of different colors provides clear direction when correlating microscopic findings with their location on the patient. The single-section method was described by Randle et al.³⁰ and minimizes the time needed for slide preparation and slide interpretation while also reducing the opportunity for error.³¹

The main factors determining when specimen subdivision is necessary are the size of microscope slides and the freezing and embedding technologies available to the technician. Convex and concave specimens, thick specimens, and specimens containing cartilage or bone usually required sectioning to be flattened into a single plane. Once appropriate sectioning has been decided, the hash marks are exaggerated, and the tissue is blotted to remove excess

water (Fig. 29-9). Dyes are applied to the nicks on the excised tissue and documented on the map that was drawn at the time of excision (Fig. 29-10). Some Mohs surgeons perform the inking themselves, while other Mohs surgeon delegate this task to their technician. Analysis of the specimen with nicks and colors provides clear direction when correlating microscopic findings with their location on the patient's defect. Inking is most helpful when the ink is placed along a significant portion of the surgical margin rather than just as an orienting dot at the specimen pole. In this situation, missing ink indicates that a margin is not fully evaluable. Most Mohs surgeons use red, blue, black, and possibly one or two other colors for this purpose. They are represented on the Mohs map with symbols for orientation purposes.

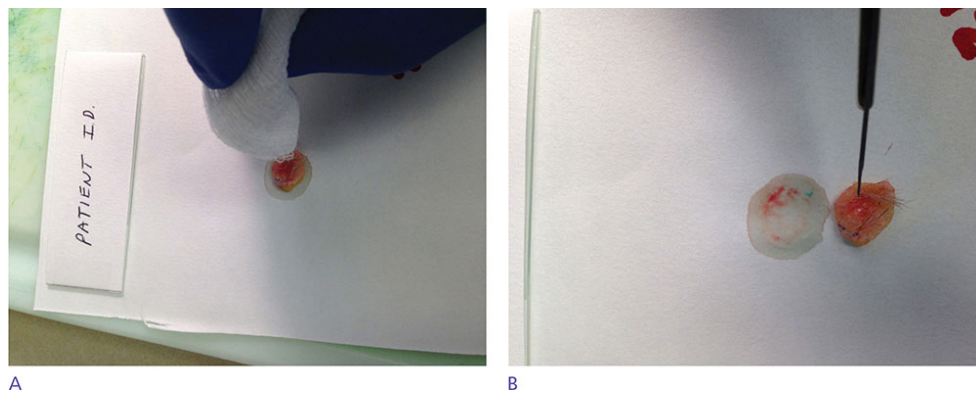


Figure 29-9. (A) The tissue is blotted to remove excess water. (B) The tissue was scored with hash marks by the Mohs surgeon during tissue removal. These small marks are enhanced by the technician to facilitate flattening the surgical margins into one plane. Along with reinforcing the existing marks, sometimes the tissue will dictate more relaxing cuts to be able to lay the entire specimen flat. When this cannot be accomplished by this technique, the tissue will be divided into sections to assure that the tissue sits on one plane, albeit in pieces.



Figure 29-10. (A) Commercially available dye system with applicators are placed in a stable holder. Once the tissue has been satisfactorily relaxed, ink is applied to the hash marks on the tissue to assist the Mohs surgeon in orientation if more stages are needed. (B) A cotton-tipped applicator is used to mark the tissue with tissue dye, which remains on the tissue through histochemical staining. When applying different colored inks to nearby tissue edges, it is good to approach the edge from the side being marked to prevent ink contamination and bleeding to unintended edges. (C) Specimen orientation, shape, reference mark location, and inking pattern are depicted on the map. In this example, XX is yellow, = is red, is green, and the four vertical lines represent blue. These symbols are used so that black and white copies can still be interpreted.

Cutting tissue into more than one section introduces a higher change of mislabeling specimens or for the Mohs surgeon to incorrectly map positive margins on the incorrect section. More sections also increase the risk of false-positive and false-negative margins.³¹

If too much ink is used, ink may inadvertently run over and confuse the margins. This may also occur if the specimen is too wet, thus emphasizing the need to blot the tissue prior to marking (Fig. 29-11). Poor-quality ink may be difficult to read and could be washed off during tissue preparation.

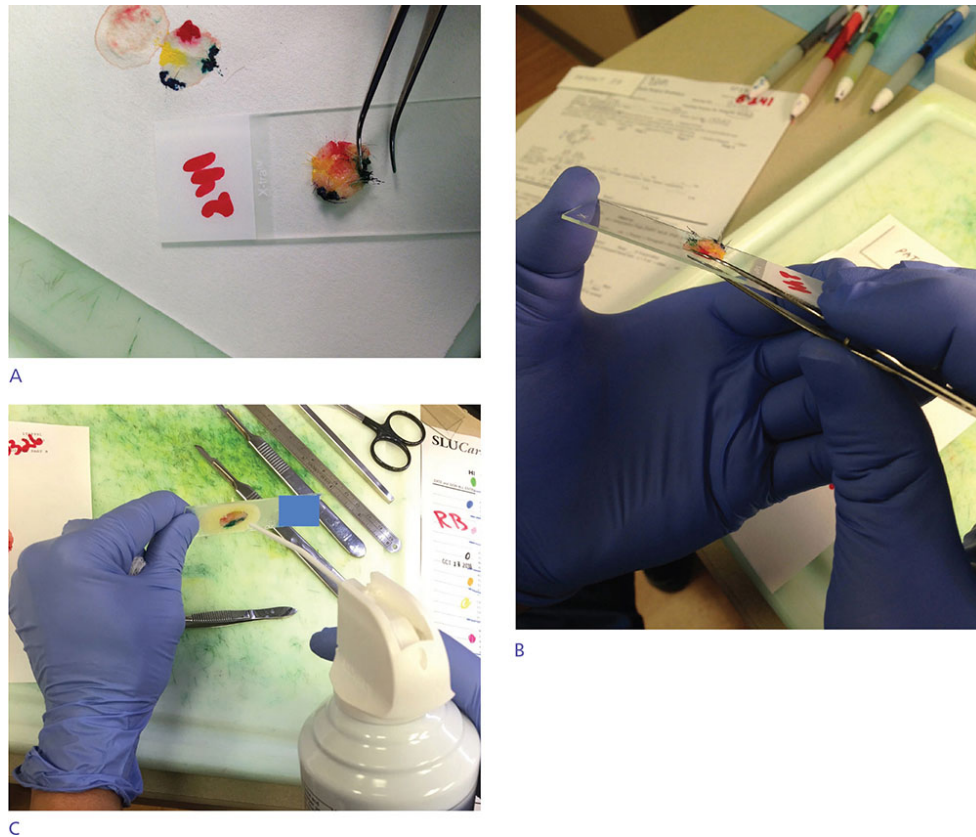


Figure 29-11. (A,B) The inked, relaxed tissue is placed on a labeled slide, deep margin down. Using forceps, the edges of the tissue are teased down flat on the slide. (C) Many times freeze spray is needed to help hold the tissue to the slide in a flat configuration. Flattening is important so that the epidermis, dermis, and subcutaneous fat lie in the same plane.

Tissue flattening

Since the specimen will be embedded horizontally for sectioning, the tissue must be flattened. For specimens that are beveled at an angle less than 45 degrees, or come from anatomic sites characterized by a thick dermis, the technician may place additional relaxing incisions in the specimen to facilitate the flattening of the section so that the plane of sectioning for the undersurface of the specimen is in the same plane as the epidermal margin. These incisions should be superficial enough to allow the tissue to flatten, but should not extend deep enough to cut the marginal surface of the specimen. Overly deep relaxing incisions may disrupt the orientation and the continuity of the margin and can introduce floaters by forcing tissue at the surface down to the base, producing a false-positive margin.

If there is inadequate relaxation of the tissue, peripheral margins may not be teased down effectively, which results in missing epidermis on the slides. In areas with thin skin, such as the eyelid, the skin may fold easily before embedding, resulting in slides that are cut tangentially and are therefore difficult to interpret.

Embedding and freezing

Once flattened, the specimen is frozen while in this level configuration and supported in a block of embedding medium, such as optimal cutting temperature (OCT) medium or a similar compound. The embedding medium binds tissue to the chuck and surrounds and supports the tissue during the cryosectioning phase. This prevents loss of tissue during processing, known colloquially as *chunking out*. The most commonly used methods to embed are the reverse slide mount method, embedding wells, and the cryo-embedder system.

The steps in the reverse slide method are as follows:

1. The tissue is mounted on a glass slide, deep side down. Full tissue contact between the tissue and the surface of the slide is assured by gently pressing the periphery of the specimen into contact with the slide and pressing out any air bubbles. This can be assisted with freeze spray to prevent lifting of the epidermis ([Fig. 29-11](#)).
2. Subsequently, a mounting medium such as OCT is applied. The tissue, embedding medium, and slide are then frozen to approximately to -15° to -30° °C. This can be assisted with liquid nitrogen, tetrafluoroethylchloride, or methoxynonafluorobutane until the medium freezes (visually turns opaque), as seen in [Figure 29-12](#).

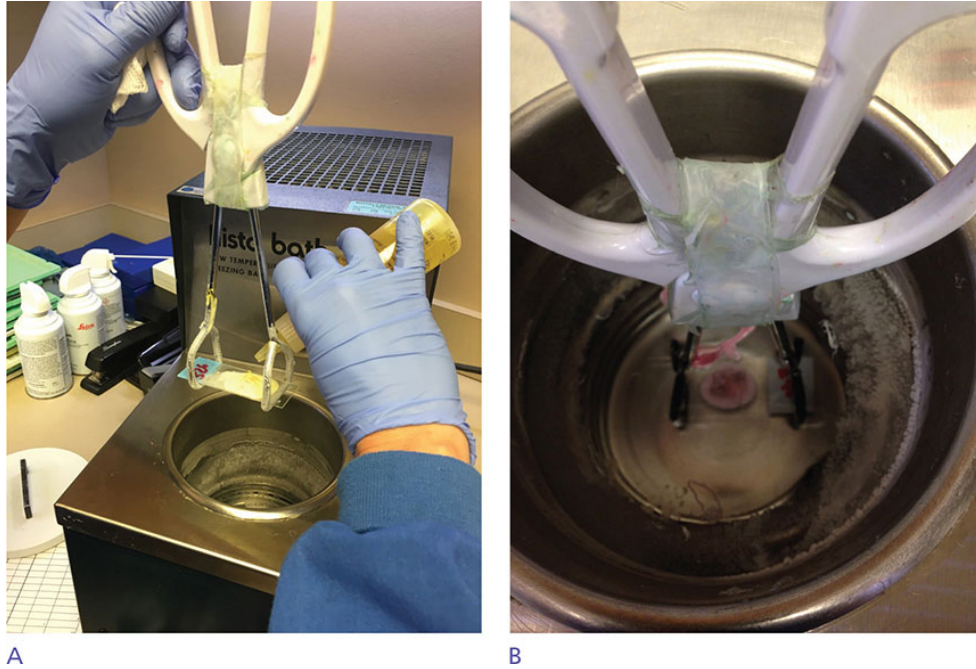


Figure 29-12. (A) Tissue is covered with an embedding compound, here OCT, which stands for “optimal cutting temperature.” Each case can be assigned a separate color of embedding medium. Yellow embedding medium is being used here. This is one way to maintain patient identification from two different sites or from two different patients. (B) The slide is submerged in the bath with a pair of tongs. The bath maintains temperature of approximately -30°C .

3. Place a small amount of embedding medium on the cryostat chuck (Fig. 29-13).

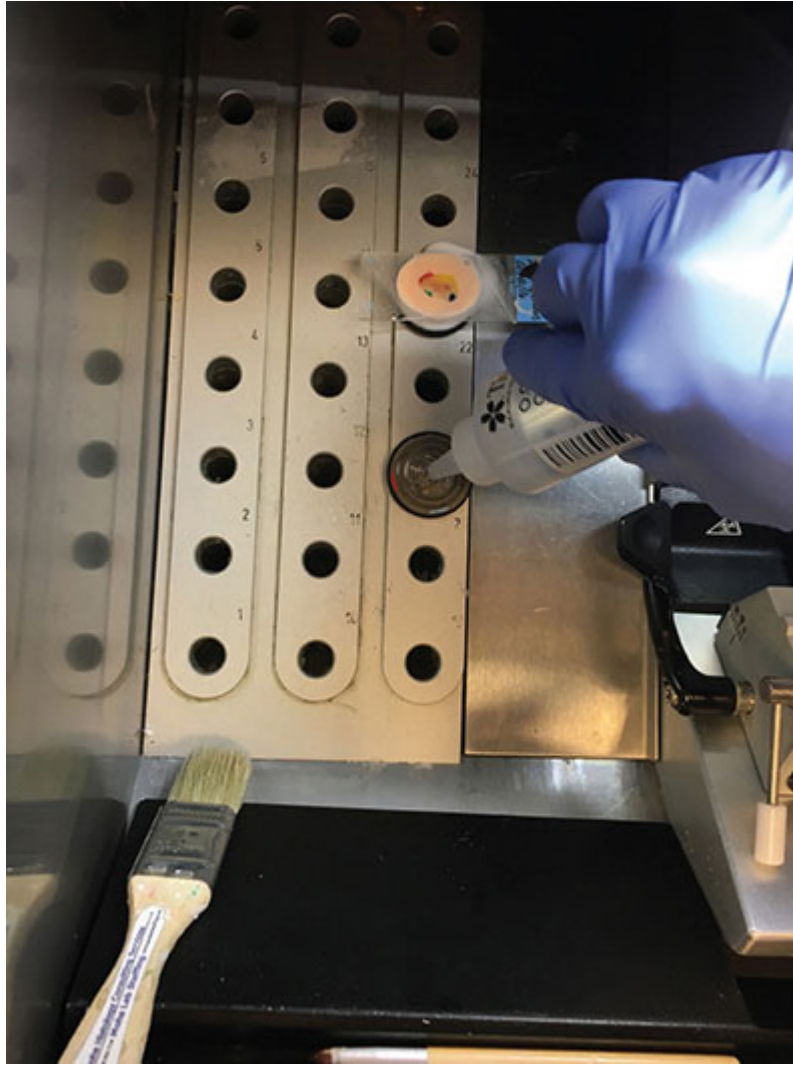


Figure 29-13. The chuck is prepared on the freeze bar with embedding medium, here optimal cutting temperature medium (OCT).

4. Invert the specimen (which is still on the glass slide) onto the chuck to create a final block. Additional embedding media can be added to the slide ([Fig. 29-14](#)). This allows the specimen to freeze to the chuck within the cryostat. A copper fitting or heat sink can be applied onto the slide. After a few minutes, the slide is removed. This reveals a smooth, level block face that should permit the deep margin and epidermal edge to be exposed in a single plane for cutting with the cryostat.

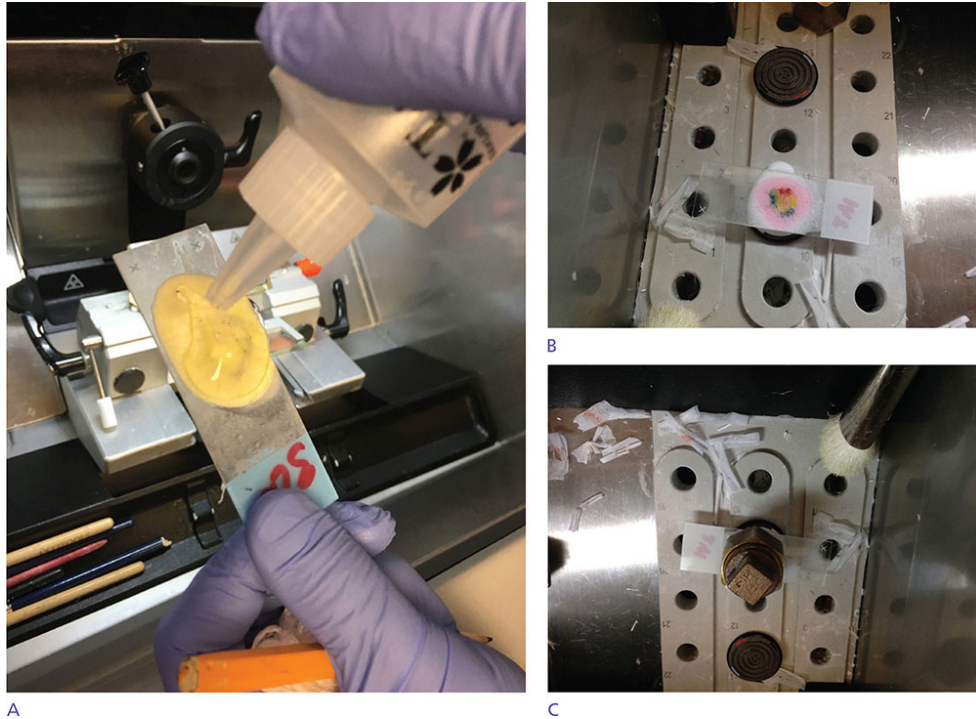


Figure 29-14. (A) Additional embedding medium is added to the tissue. (B) The specimen is placed upside down on the chuck with more embedding medium. It is allowed to cool further. (C) A heat sink or extractor is used to speed up the freeze process. After a few minutes, one can pop the slide off the tissue for embedding, leaving the surgical margin of the tissue exposed, all in one plane. If the slide resists popping off the embedding medium and tissue, a warm thumb can be used to warm the glass slide to separate it from the frozen block. A film of embedding medium can be applied to fill any open gaps in the block face for smoother sectioning and to prevent tissue from chunking out.

5. Place the specimen block in the cryostat to begin cutting the tissue (Fig. 29-15).

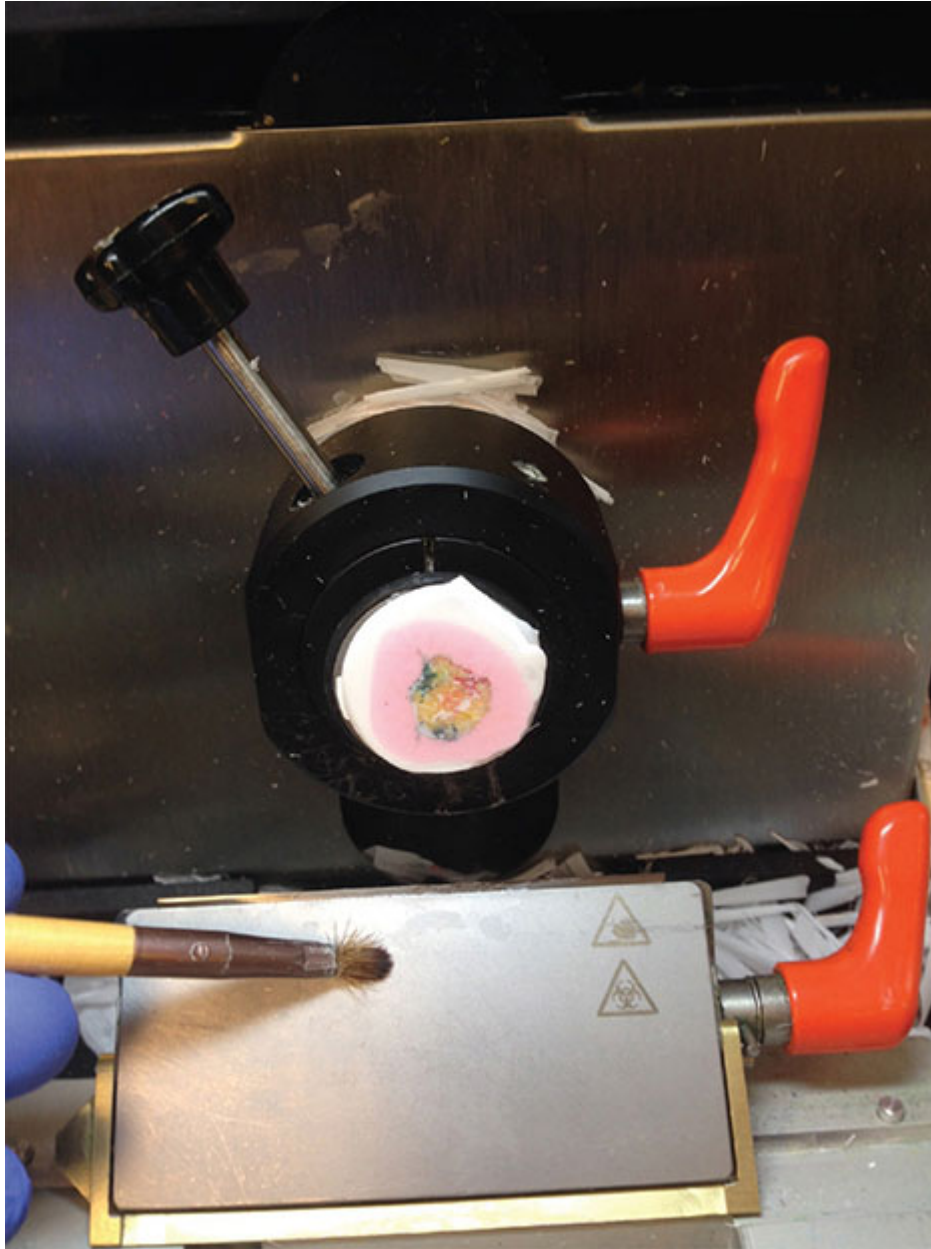


Figure 29-15. Once the slide is off, the chuck is ready to be placed in the object holder of the microtome. It is screwed down by the arm with the black/silver knob and then the angle of the tissue to the blade is adjusted with the red handle to the direct right of the tissue.

If the tissue is frozen too slowly, ice crystals can leave holes in the tissue. Condensate that accumulates in humid conditions can also result in ice crystal formation that causes cracks and holes in the specimen. Curling of the specimen may occur if the cutting blade in the cryostat is not cold enough, or if there is high humidity in the room.

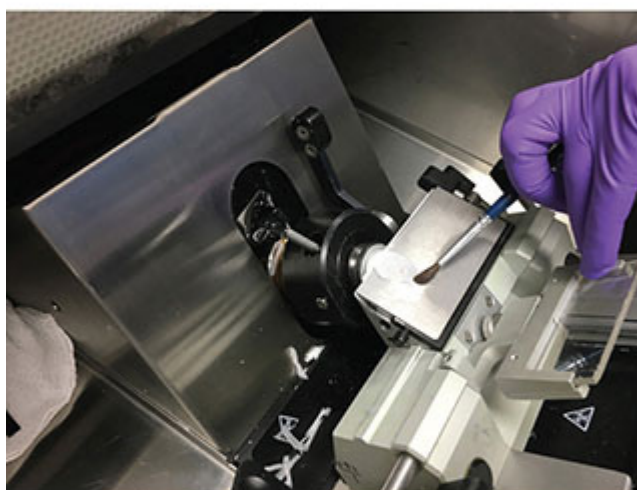
Fatty tissue may require intense freezing, which can lead to an increase in epidermal freeze artifact, tissue fractures, and specimen chipping.

Cutting and slide fixation

Once the specimen is embedded and frozen in the medium and mounted on the stage, it is sectioned in the microtome and placed on the slide (Fig. 29-16). The clamp usually has a ball-and-socket joint that allows for minor adjustments in specimen alignment with respect to the blade, and one must ensure proper angle of blade prior to trimming into the block. When first beginning to rotate the microtome blade, the outer layers of OCT must be cut away until reaching the actual specimen; this procedure is often termed *facing the block*. Upon reaching the specimen, it may require realignment to create uniform slides. If the undersurface of the specimen on the chuck is not parallel to the blade early in the cutting, incomplete sections and consequent deeper sectioning requirements may result. Once the embedding medium has been adequately trimmed, horizontal 5- to 10-micron sections (section depth varies with personal preference) are affixed to the slides. Thick sections are difficult to read as cellular detail may be obscured, although fatty tissue may call for thicker sections, while thin sections may introduce holes or tears that are visible. The first slide is of utmost importance as it represents the true margin, since the tissue is cut from the deep margin upwards toward the surface of the skin with each turn of the blade. Ensure that the technician counts the number of turns of the wheel and knows the number of microns per turn in order to properly calculate the depth of the tissue. On average, two slides are made with two to three sections per slide. Most surgeons like to see three to six sections total.³²



A



B





Figure 29-16. (A) Sections are taken on the roller plate by turning the cryostat wheel. (B) The brush is sitting on the roller plate. Horizontal sections are taken in a bottom-up approach so that the first few sections are a representation of the true surgical margin comprising both skin edge and deeper tissue. (C) The tissue is then transferred to a glass slide.

Of note, fat does not become solid enough to cut well at temperatures that are best for cutting most other tissues. The technician may, therefore, spray the embedded fat-containing specimen with a cryogen to lower its temperature before cutting, rather than resetting the cryostat temperature.

Nearly all problems with wrinkling and folding arise when the specimen is advanced across the blade and when picking up the wafer for placement onto the slide; therefore, the technician must ensure that the cut wafer is properly retrieved. There is a tendency for frozen tissue to curl before it is placed on a glass slide. The curling can be mitigated by the use of antiroll bars (which prevent specimens from curling out of the plane of section) or plates, and/or camel hair brushes, which are kept in the cryochamber on the brush shelf.

Dull blades can cause tearing or curling of the tissue, or even lead to chatter lines in the tissue as they cut. A microscopic nick in the edge of the blade can create a large tear in tissue. Therefore, it is important to check the blade for nicks, and to sharpen the permanent blades and move disposable blades along the blade holder throughout the day.

If the blade is not clean, floaters may be introduced by the blade. These floaters may be present on multiple slides and can therefore be difficult to recognize as floaters.

When sliding sections from the blade onto the slide, additional errors may occur. After placing each section on the slide, extra embedding medium should be wiped off the glass slide before placing the subsequent section. If the next section is placed over the embedding medium of the previous section, it may not adhere properly during fixation and can be washed off during staining. If the next section overlays embedding medium over the

previous section, it may interfere with proper staining. To prevent this, when applying more than one section to a slide, it is common to begin in the upper corner and place sections diagonally across the slide.

Excessive facing of block produces false-negative and false-positive reads. If the specimen is not properly flattened, and a high area of tissue is cut away, then the true margin is forever lost. If the true margin contained tumor, a false negative may result. If the true margin was free of tumor, a false positive may result. Always use high-quality glass slides, as if glass slides are flawed tissue may not adhere properly. Charged slides (so-called *plus slides*) may be used to improve tissue adherence.

Staining

Slides must be stained so that the otherwise colorless cellular material can be visualized through a light microscope. Mohs slides are generally stained with hematoxylin and eosin (H&E), toluidine blue, or occasionally with special immunohistochemical stains for routine histologic analysis. H&E is the most commonly used tissue stain in MMS. This involves placing the tissue in a series of solutions: alcohol, water, xylene, hematoxylin, and eosin. In high-volume laboratories using H&E, they are placed in an automatic slide stainer to decrease the processing time (Fig. 29-17). Toluidine blue highlights islands of BCC by metachromatically staining its surrounding mucopolysaccharides a vibrant pink.³³ After the slides have been stained, they are cover-slipped. A glue-like medium is applied, followed by a thin glass cover slip that protects the tissue from being accidentally scratched off and preserves the slide for years.



Figure 29-17. Automated hematoxylin and eosin staining device with three slides being actively stained. Once the tissue section is picked up off the roller plate by pressing one of the relabeled slides to it, the slide is stained. The stain sequence is shown above. The slide transitions from fixatives, to hematoxylin, to bluing agent, to eosin, to alcohols, to xylene. Finally, the slides are coverslipped, matched with the requisition, and presented to the Mohs surgeon for interpretation.

If slides are moved too quickly from the fixative (usually alcohol), they will not dehydrate appropriately, resulting in suboptimal staining.

Immunohistochemistry is also used by some surgeons for treating more challenging tumors. These include cytokeratins for SCC and Paget's disease and CD34 for dermatofibroma sarcoma protuberans.^{34,35} For melanoma, frozen section interpretation can be facilitated by HMB-45,³⁶ MART-1, and S-100 for desmoplastic subtypes,³⁵ MITF for its superior nuclear staining,³⁷ and mel 5.³⁷ Overall, MART-1 is the most useful stain for melanoma.³⁸ The cost of reagents, unavailability of automated staining equipment, additional processing time, and additional technician skill and time, have slowed the widespread adaptation of immunostains by Mohs surgeons.³⁹ Regardless of whether immunostains are used during Mohs surgery, permanent sections may be obtained for additional confirmation of clear margins in more challenging

cases. A full discussion of immunohistochemical stains for MMS may be found in [Chapter 30](#).

During staining, a floater can be introduced from contamination of the staining solution. This floater will randomly appear (not necessarily contiguous with the specimen). Changing the staining solution regularly minimizes the introduction of floaters.

Mapping the tumor and interpreting the slides

The names and accession numbers on the slides should be checked to be sure that they correspond to the names and accession numbers of the Mohs maps on which the interpretation of these slides is to be entered. Only after ensuring the correct slides are being read may the Mohs surgeon begin to interpret the slides.

Interpretation of Mohs slides is the most critical step in MMS; a technically superior section is demonstrated in [Figure 29-18](#). Scanning of Mohs slides should evaluate all tissue sections on the slide in a systematic way by examining all the peripheral and deep margins. Verify that a complete epithelial edge and deep margin are present. Mohs surgeons should be facile in identifying different cutaneous structures and in detecting various skin neoplasms, skills that are teachable, and consistently improve with training and experience.⁴⁰

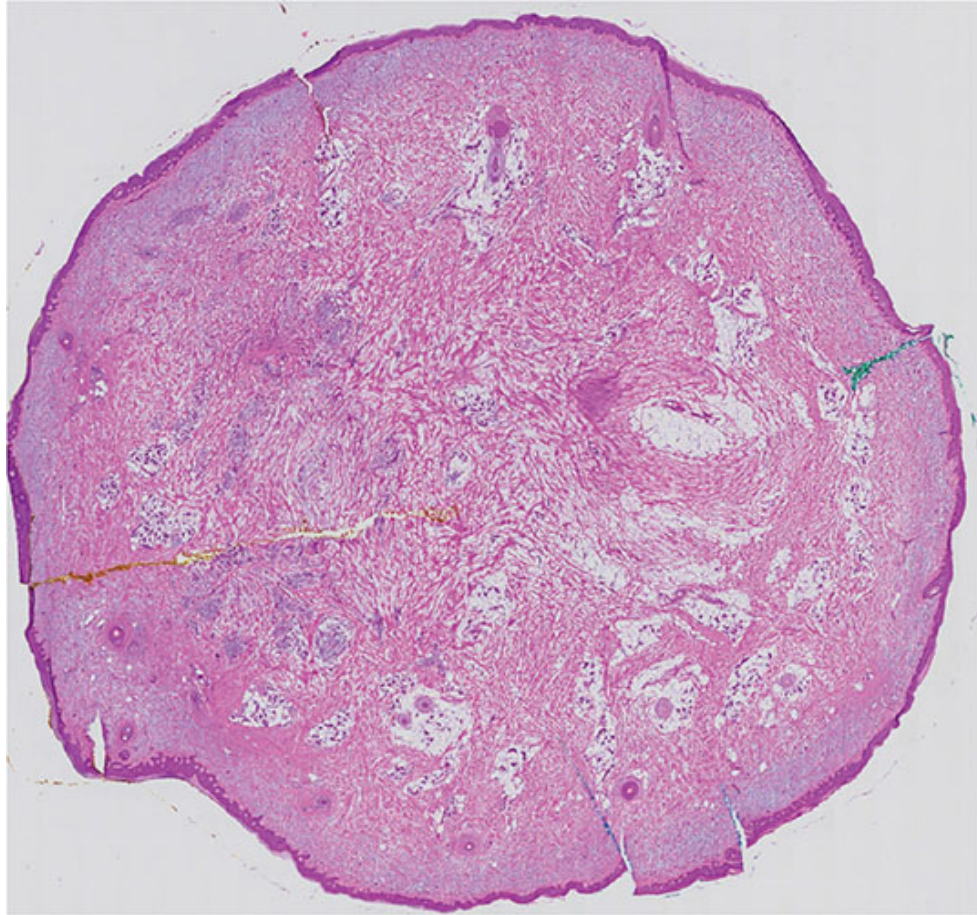


Figure 29-18. Hematoxylin and eosin stain of a frozen section depicting the excised surgical margin. The inks used are clearly visible, and the epidermis, dermis, and subcutaneous fat are all seen and evaluated in the section. In this case, no tumor is seen.

Errors may occur by misinterpreting floaters as positive margins (Fig. 29-19); misinterpreting benign structures such as hair follicles, parotid gland, lymph nodes, and other adnexal neoplasms as BCC (Fig. 29-20); misreading actinic keratosis or scar as SCC; mistaking granulation tissue or fibrosis for a spindle cell neoplasm; and reading benign structures such as seborrheic keratoses and warts as SCC (Fig. 29-21). Certain anatomic areas, such as the eyelid, have unique histology, particularly when read in horizontal sections, that can be misinterpreted as tumor (Fig. 29-22).

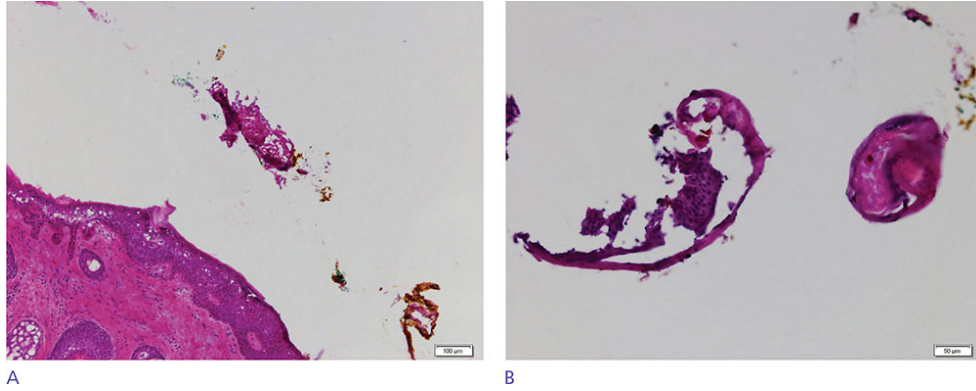


Figure 29-19. Floaters may be introduced during curettage, nicking, cutting tissue, and staining tissue. (A) 10× and (B) 20× views.

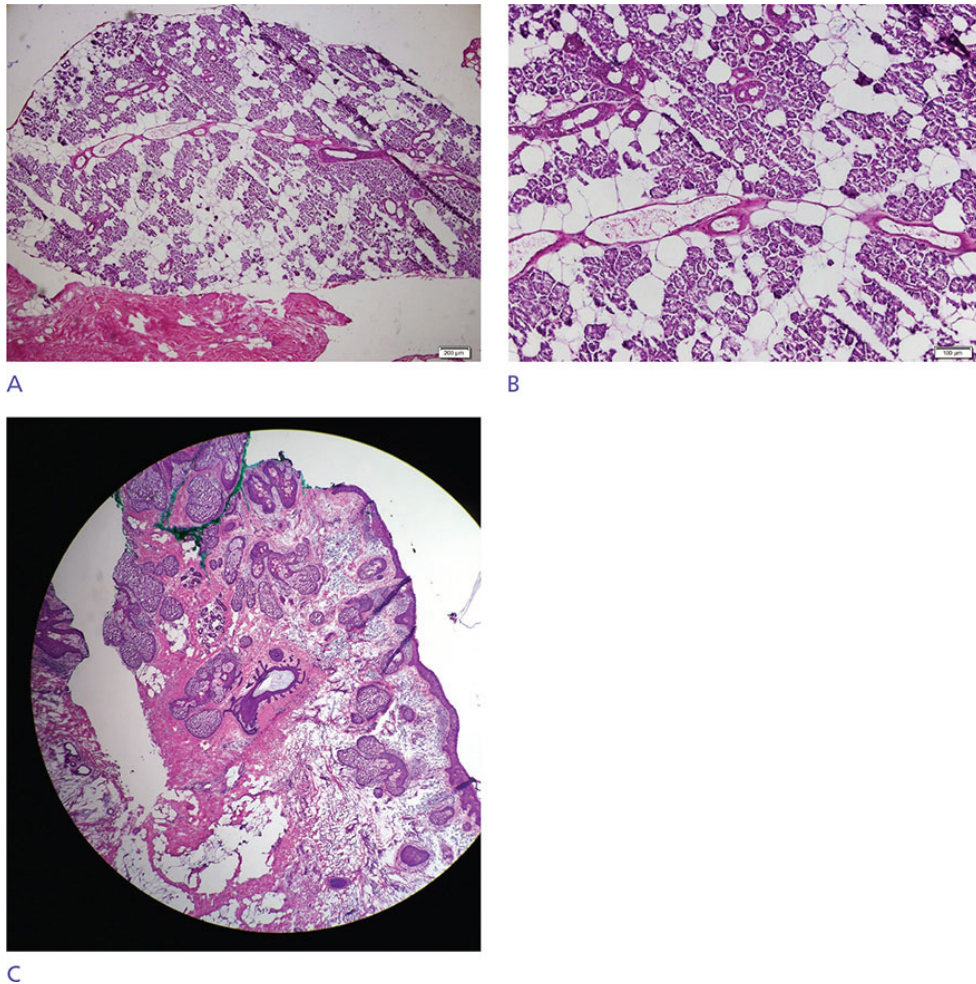


Figure 29-20. The dark blue cells of the parotid gland can be mistaken for tumor. (A) 4× and (B) 10× images of parotid tissue reveal glandular elements not seen in BCC. Note lack of palisading and retraction artifact. (C) View of a Mohs section showing a follicular basaloid proliferation with irregular

strands of basaloid cells emanating from a hair follicle. It has a characteristic pin wheel appearance. There is also lack of cleaving adjacent to the cells, apoptosis or mitotic figures as well as the presence of a fibrous sheath.

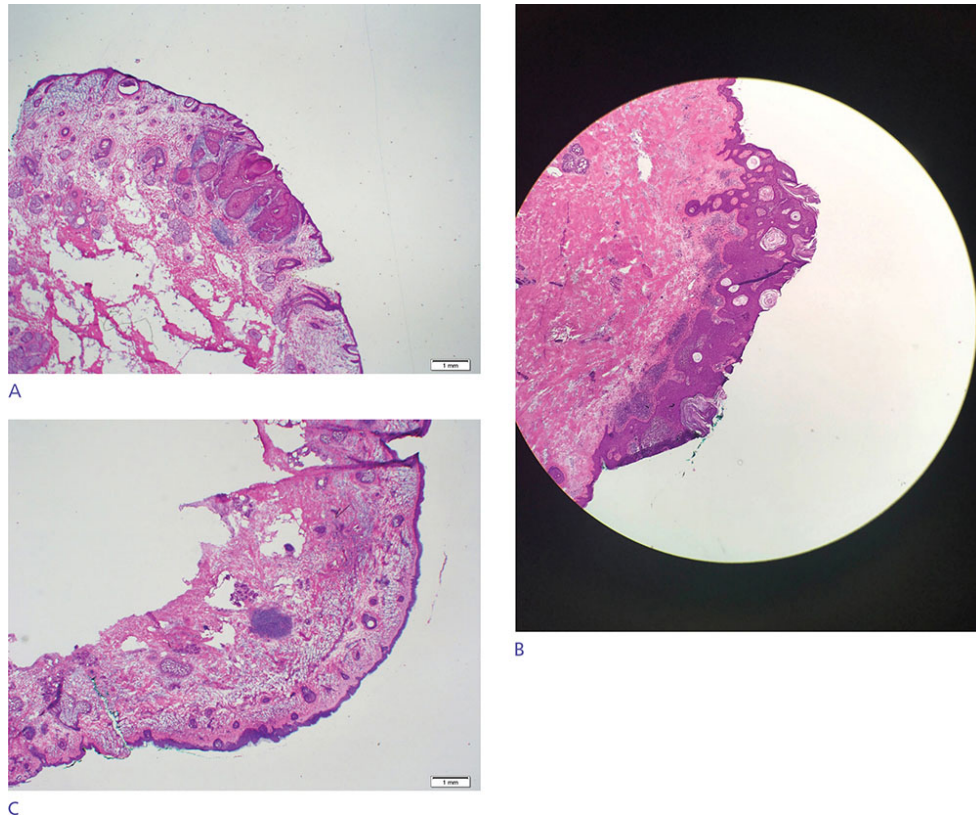


Figure 29-21. (A) Squamous cell carcinoma, which can be confused with (B) a seborrheic keratosis. (C) A focus of dense inflammation around a hair follicle can also be misread as a positive margin. Additional cuts usually reveal a benign structure.

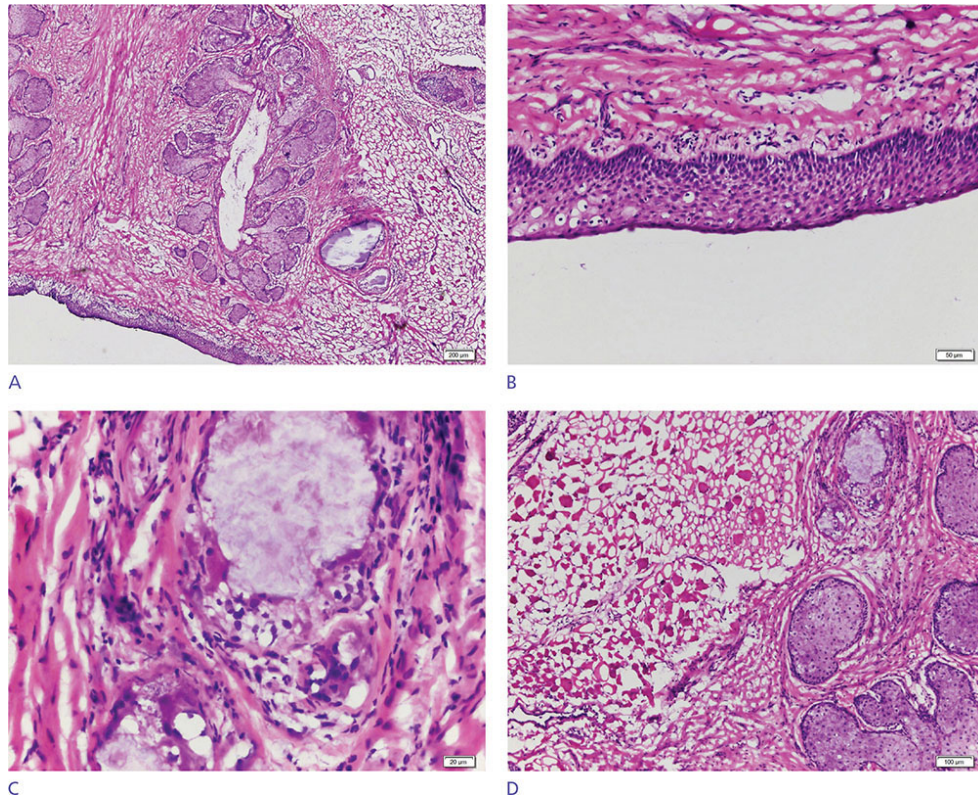


Figure 29-22. (A) Conjunctiva with meibomian glands and ducts 4×. (B) 20× mucus-producing goblet cells of the conjunctiva may be misinterpreted as melanocytes, Paget's disease, or Bowen's disease. (C) Apocrine gland of Moll 40×. (D) Pyknotic muscle fibers may simulate SCC, especially when viewed singly. Note the preserved lobular architecture.

The success of MMS is contingent upon the presence of high-quality frozen tissue sections, and artifacts may make reliable slide interpretation challenging (Fig. 29-23). Recognizing the artifact allows the Mohs surgeon to account for it and make the correct interpretation. Overlooking a section of tissue or evaluating a suboptimal slide with missing tissue or containing a substantial hole has been associated retrospectively with tumor recurrence.²⁵

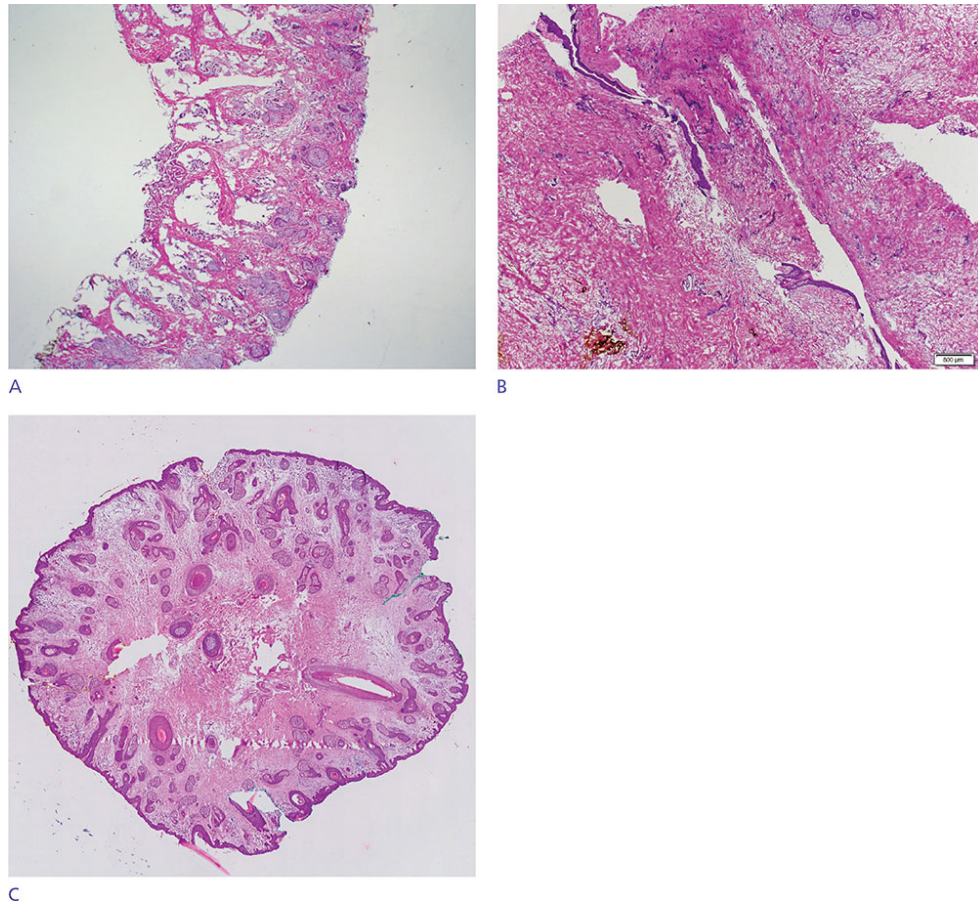
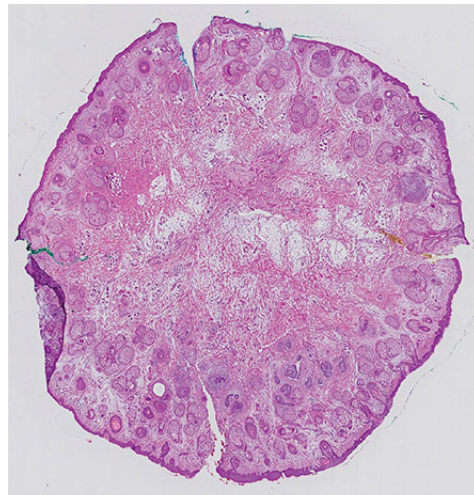
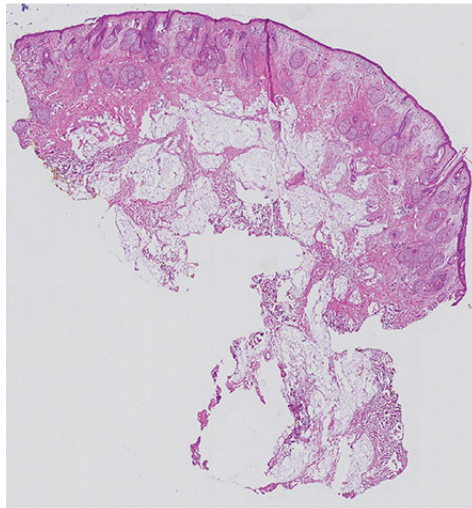


Figure 29-23. Technical errors with slides. (A) Missing epidermis. (B) A large recurrent cancer with epithelium from the center of the specimen implanted into the deep margin of the Mohs section, mimicking a positive deep margin. (C) A chatter line from a defect in the blade.

If a positive margin is detected, the Mohs surgeon marks the positive areas on the two-dimensional map (Fig. 29-24). An additional layer of skin is excised in the area where tumor was identified. This is accomplished by noting the inked nicks and corresponding sites marked on the map. The process of excising, mapping, and sectioning additional layers of skin is repeated until no additional tumor is identified. Subsequent layers are taken only in the areas involved by tumor with an overlap width of 1 to 3 mm in order to maximally spare uninvolved tissue. Once negative margins are achieved, appropriate reconstruction can be contemplated.



A



C

Mohs Surgery Worksheet

Day Surgery ☒ Y/N ☐ Lesion Exam ☐ A

Diagnosis: BCC / SCC / SCC in-situ / other: _____ Latex Allergy: NO

Site: inf. central ft ☐ Clinical tumor present ☒ Scar only
 Patient's site and patient identity have been confirmed, and are in agreement with the patient's family was able to confirm site, and are in agreement with the indication ☐ Tumor Location ☐ Tumor Size ☐ Aggressive H

Size: 1.0 x 1.1 cm 1.8 x 1.7 cm
 Size: 1.5 x 1.3 cm

Defect: dermis / fat / fascia / muscle / perichondrium / cartilage / periosteum / #Slides 1/2 Y/N

Confirmed: BCC 3cc

Pre-Op OK Defect _____ Repair _____

B

Figure 29-24. (A) A focus of basal cell carcinoma is seen between the red and yellow nicks on stage 1. (B) This is indicated with red pencil on the map. A second layer is taken in the area with tumor and is indicated on a separate map to the right of stage 1. (C) The second stage is clear of tumor, so no red penciled areas are seen on the map for stage 2.

Inflammation may make minute cancer foci challenging to see. Requesting thinner slide sections may help, though with aggressive tumors, immunohistochemistry (either on permanent sections or on frozen Mohs sections) can be occasionally helpful. Patients with a history of chronic lymphocytic leukemia or solid organ transplant have a 36% and 13% incidence, respectively, of prominent inflammatory foci on Mohs sections compared with controls (1%), making slide interpretation more difficult.⁴¹

Some Mohs surgeons prefer to limit the use of electrocautery, as excessive cautery may lead to elongation of the nuclei and cytoplasm of epidermal cells and adnexa, as well as basement membrane retraction artifact, histologically mimicking BCC. Moreover, cautery induces local inflammation that may be challenging to distinguish from tumor-induced inflammatory reactions.

Additionally, if the tumor has excessive epidermis centrally (as can happen with recurrent tumors and/or partially treated tumors), these cells may be pushed up to the surface and be misinterpreted as residual tumor.

When approached with the difficulty of determining the distinction between basaloid follicles and tumor, serially sectioning of the tissue specimens allows one to further differentiate normal adnexal structures from tumor nests.

When taking an additional Mohs stage due to the presence of a positive margin on a previous stage, the surgeon should overlap the diagrammed extent of the positive margin to provide a margin of error. Keep in mind that frozen tissue section processing results in approximately 10% to 20% tissue shrinkage.

If perineural invasion is seen, the subsequent stage must include *both* peripheral and deep tissue, *and* the nerve must be visualized in the subsequent stage, before that margin can be called clear. This is because nerves can travel vertically or horizontally. Examples can be seen in [Figures 29-25](#) and [29-26](#).

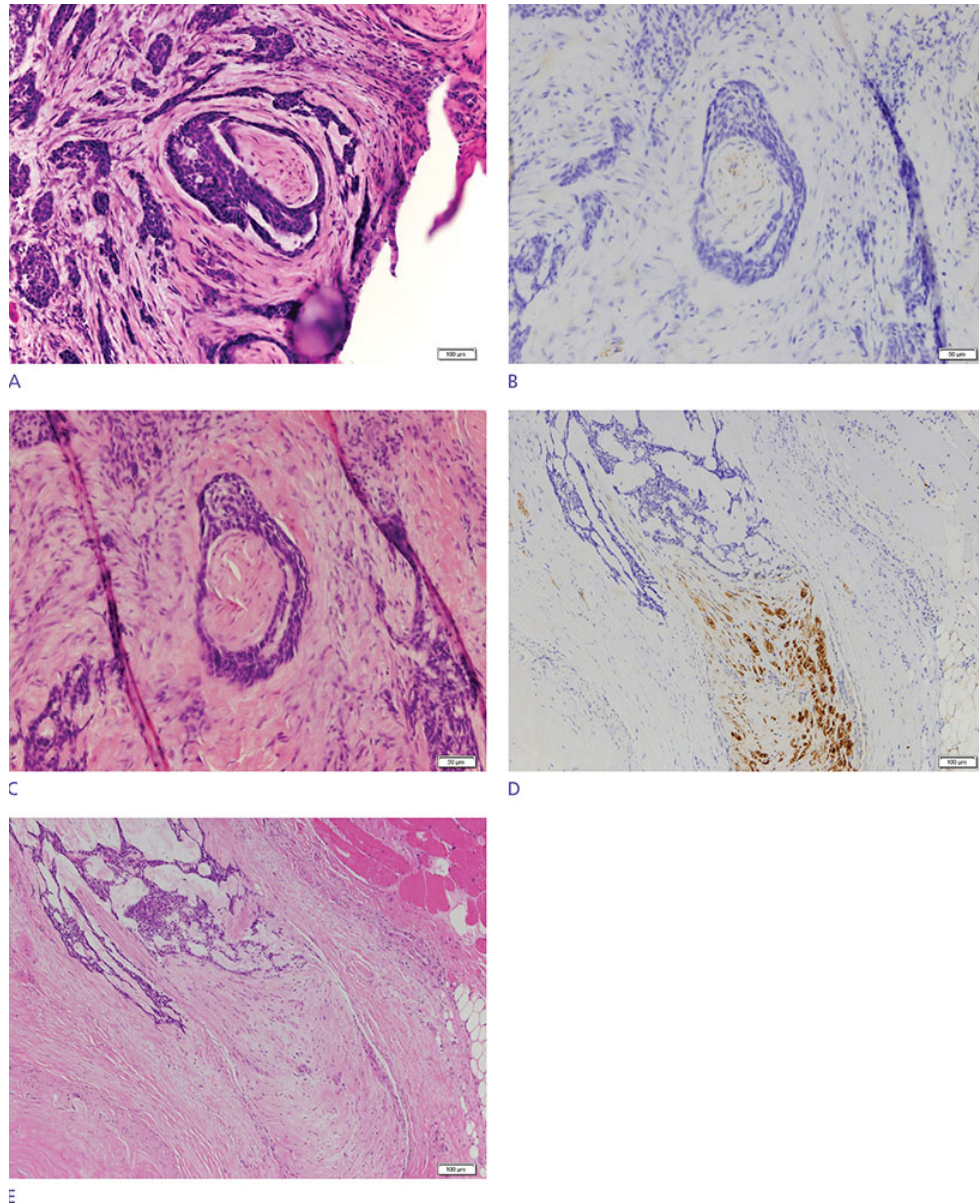


Figure 29-25. Perineural involvement. Basal cell carcinoma with a halo of basal cells invading a cutaneous nerve. (A) 20× demonstrating BCC invading a nerve on frozen section. (B) S100 stain on permanent section highlighting the nerve stained brown with BCC within the nerve sheath. (C) 40× permanent section of the same nerve seen in A and B. (D) S100 stain demonstrating a large nerve invaded by BCC. (E) Permanent section of the same BCC invading the large nerve seen in D.

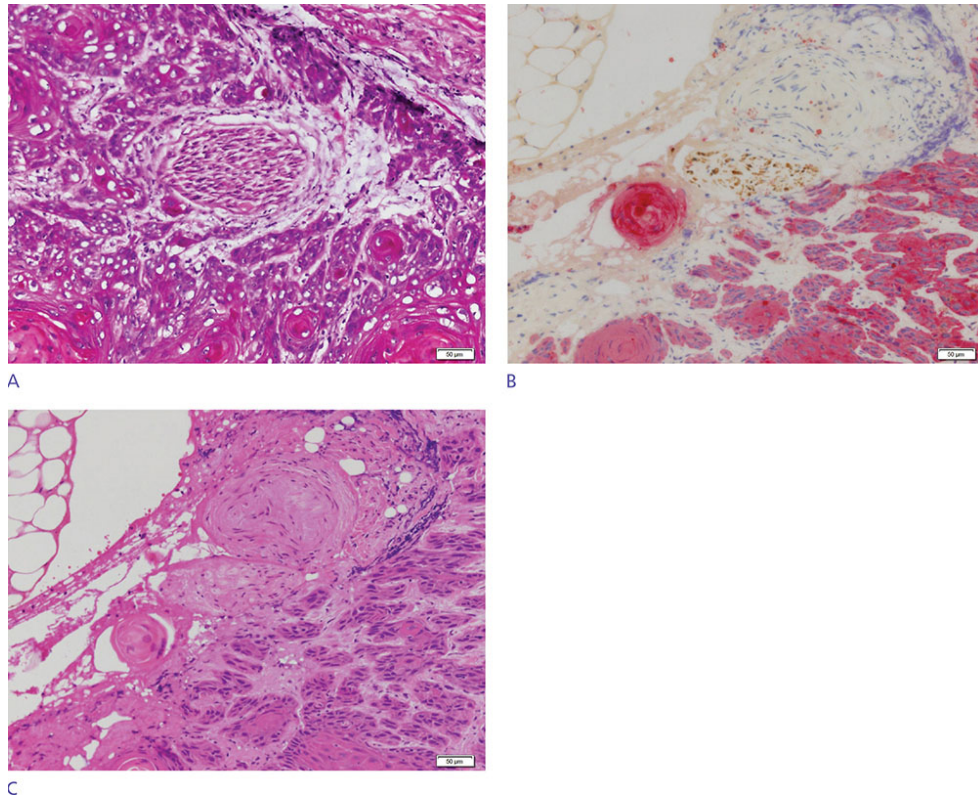


Figure 29-26. (A) SCC surrounding a nerve fiber on frozen section at 20×. (B) Immunohistochemistry demonstrates the nerve, stained brown with S100, is uninvolved with SCC, which is stained red with cytokeratin. This can be easily misinterpreted as perineural invasion of SCC on frozen section. IHC was necessary to make a diagnosis in this case. (C) A permanent section of the same field is provided for comparison.

ADVANTAGES OF MOHS SURGERY OVER EXCISION

Cancer surgery is predicated on the assumption that tumor growth is spherical, a theory that is not entirely accurate for many cutaneous tumors. This model does not account for embryonic fusion planes and other tissue planes that may present a temporary barrier to tumor spread. As a consequence of this, the growth and configuration of skin cancers are often asymmetrical and irregular. Such asymmetrical tumors are better removed with MMS with its attendant meticulous and precise tumor removal.

In conventional processing of excisions, histologic sections are generally obtained vertically using a bread-loafing technique. This involves *sampling* sections of skin, and is estimated to examine only 0.1% to 1% of the total

histologic margin, and can therefore result in false-negative results. This contrasts with the horizontal sectioning of Mohs surgery, which examines 100% of the margin. This approach, therefore, offers a clear advantage in lowering the chance of recurrence.

Furthermore, the mapping of 100% of the surgical margin allows the surgeon to precisely control all margins and adopt a tissue-sparing technique. By contrast, for BCCs less than 10 mm in diameter, conventional excision requires 4-mm margins to obtain a 95% cure rate and larger, sclerosing or recurrent BCCs required 13- to 15-mm margins to reach a 99% cure rate.⁴² These margins may unnecessarily involve anatomic structures, such as nerves, cartilage, tendons, and muscle. One study showed that the median area of the surgical defect produced during MMS for the treatment of nodular BCCs was significantly smaller than that of conventional surgical excision (116.6 mm² vs. 187.7 mm², $p < 0.001$),⁴³ facilitating a more straightforward repair of the defect. Using Mohs surgery to possibly conserve these structures enables the surgeon to conduct more sophisticated and perhaps more cosmetically elegant reconstructions immediately after resection.

COMPLICATIONS

Complications of Mohs surgery are rare, and are mostly related to post-Mohs reconstruction. These include some degree of bruising, swelling, scarring, dysesthesia, and postoperative discomfort. Rarely, edema and dysesthesia may be persistent, though this normally returns to baseline in a few to several months. All potential complications should be discussed with the patient prior to the initiation of surgery.

Bleeding

Bleeding is the most common post-Mohs surgery complication, and its risk is increased in patients taking anticoagulants. Still, there is no evidence that patients taking aspirin or warfarin for serious medical problems experience increased risks of *serious* hemorrhage or bleeding complications. Patients on thienopyridines such as clopidogrel or ticlopidine undergoing dermatologic surgery are, however, at increased risk of bleeding complications.^{44,45} These minor complications include partial necrosis in 1.7% of flap closures and

8.6% of graft closures (with no instances of complete necrosis or need for subsequent revision), and a 0.73% rate of dehiscence. Such complications are generally managed straightforwardly in the outpatient setting. Therefore, medically necessary anticoagulants are typically continued in the perioperative period in order to prevent thrombotic events.

Infection

If a Mohs wound is left open to heal by secondary intention, the rate of infection is very low. For example, Lawrence et al. allowed 67 relatively large wounds left open to heal by the second intention following skin cancer excision and observed infection in only two cases,⁴⁶ and Mohs surgeons are generally skilled at assessing whether a wound is appropriate for secondary intention closure.⁴⁷ Most studies examining infection rates, however, include both Mohs surgery and reconstruction. Wounds sutured closed create dead space and introduce foreign material into the wound, making them more likely to become infected. Despite this, infection occurs in only 1% to 2% of cases,^{48,49} with higher rates seen in patients with excessive bleeding or hematoma formation. Some studies have suggested that intra-incisional injection of nafcillin or clindamycin after Mohs surgery and prior to surgical reconstruction may reduce the risk of postoperative infection.^{50,51} Prophylactic antibiotics are not routinely recommended unless there is high risk of infective endocarditis, hematogenous joint infection, or surgical site infection.¹⁹

Scarring

Scarring from MMS is often seen as the most significant sequela of the procedure from the patient's perspective, and is dependent on both the extent of tumor-induced tissue destruction and closure technique. Hypertrophic scarring, keloids, widened scars, and scars demonstrating pigmentary changes are all possible, and counseling the patient prior to surgery is imperative in setting appropriate patient expectations.

Nerve damage

Sensory nerve loss often occurs during Mohs surgery, because small sensory fibers are severed during tumor excision. Such deficits are usually short term owing to regeneration of the nerve fibers. Motor nerve damage may occur when tumors invade or surround the nerve and must be sacrificed. Regardless, a detailed knowledge of anatomy is important to avoid these structures when possible and to warn patients when nerve compromise may be imminent.

Lidocaine toxicity

Lidocaine toxicity must be avoided during MMS. Careful record keeping is critical, especially in large tumors that require several stages to clear. Clinical signs of lidocaine toxicity include talkativeness, perioral paresthesias, tinnitus, vomiting, tremors, seizures, and ultimately cardiopulmonary arrest. To prevent this complication, the maximum lidocaine dose in adults of 5 mg/kg for plain lidocaine and 7 mg/kg for lidocaine with epinephrine should be observed.

Cerebral emboli

Lethal complications of Mohs surgery are rare, but two cases of cerebral emboli have been described following MMS for scalp tumors.⁵² To prevent this complication, patients with exposed calvarium (stripped periosteum) require careful patient positioning in the supine or prone position to limit negative pressure gradients that may occur via the noncollapsing veins of the head and neck such as the epiploic veins and the emissary veins that drain to the dural venous sinuses. The majority of neck and scalp incidences of air embolism occur via the posterior venous complexes; therefore, caution should be taken with Mohs defects with stripped periosteum on the posterior scalp to keep these patients flat during surgery and while waiting in between stages.⁵³

NEW DIRECTIONS

Evidence supports the use of MMS for the treatment of melanoma and rarer cutaneous malignancies, such as dermatofibrosarcoma protuberans, atypical

fibroxanthoma, microcytic adnexal carcinoma, malignant fibrous histiocytoma, adenocystic carcinoma, apocrine/eccrine carcinoma, mucinous carcinoma, leiomyosarcoma, and sebaceous carcinoma.⁶ Among these tumors, MMS is being increasingly used as an alternative to standard excision for certain melanomas. Melanocytes are difficult to assess on routine frozen section,³⁸ but with advances in immunohistochemistry, Mohs surgeons overcome this challenge by using special stains that better highlight these cells. Kelley et al. reported 100% correlation between paraffin-embedded permanent sections and frozen sections stained with MART-1.⁵⁴ As laboratory-staining techniques improve, Mohs surgery may play an increasing role in the treatment of melanoma. For a full discussion of Mohs approaches to melanocytic lesions, see [Chapter 31](#).

CONCLUSIONS

Understanding the fundamental techniques of MMS permits the physician to appreciate the specific instances when patients will best benefit from this procedure. The techniques of MMS have continued to evolve since its introduction by Dr. Frederic Mohs, and some variation persists between Mohs surgeons. A significant benefit of this approach is that the Mohs surgeon serves as the pathologist, lowering the potential for human error in a situation where tissue orientation is of critical importance. The accuracy and skill applied at each step of the procedure lead to the consistently high cure rates balanced by maximal tissue conservation. Newer directions, particularly the use of immunohistochemical stains to permit effective treatment of melanoma, continue to permit this technique to remain at the cutting edge of dermatologic surgery and surgical oncology.

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CHAPTER 30 Advanced Techniques and Special Stains in Mohs Micrographic Surgery

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Benjamin Jones
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SUMMARY

- Micrographic surgeons must have a working knowledge of pathology techniques including immunohistochemical stains and newly developed and developing molecular diagnostics.
- From a practical standpoint, with the exception of lentigo maligna (and potentially superficially invasive melanomas), there are few tumors that benefit from the addition of frozen section immunohistochemistry at the time of micrographic surgery.

Beginner Tips



- Maintain regular contact with colleagues in dermatopathology. The perspective of the pathologist and surgeon must be mutually understood.
- Personal visits are better than phone calls which are better than e-mails which are better than text messages.

Expert Tips



- Poorly differentiated tumor cells, dense inflammation, perineural invasion, and fibrosis are all situations in which immunohistochemical stains may be useful. The most widely used is AE1/AE3, a pan-keratin marker, which will label most carcinomas.
- If there is specific concern for BCC, a Ber-EP4 stain can be performed.
- CK7 for EMPD may be helpful in Mohs frozen sections. The main caveat to using this stain is the usually large sizes of the pieces of tissue to be examined in EMPD.

Don't Forget!



- New terms are introduced into the literature by both clinicians and pathologists in an attempt to better define pathological entities and stratify risk. In recent years, the terms atypical intradermal smooth muscle neoplasm (instead of cutaneous leiomyosarcoma) and pleomorphic dermal sarcoma/undifferentiated pleomorphic sarcoma have been introduced. Pleomorphic dermal sarcoma/undifferentiated pleomorphic sarcoma is a distinct entity from AFX and has a worse prognosis.

Pitfalls and Cautions



- CD34 as a frozen section immunohistochemical stain for DFSP treated by MMS is discouraged. The nonspecific background staining, as well as the labeling of endothelial cells, makes this extremely difficult to interpret on frozen section pathology.
- Some tumors may also benefit from adjuvant therapy, such as postoperative radiation.

Patient Education Points



- Patients should be explained that many rarer or more aggressive tumors have a high defect to lesion ratio, so an ostensibly small tumor may end up leading to a very large defect.
- The high cure rates cited for Mohs surgery are generally applicable to primary low-risk tumors; tumors with negative prognostic factors (infiltrative or perineural patterns) or unusual tumor types (Merkel cell carcinoma, DFSP) may be associated with significantly higher recurrence rates.

Billing Pearls



- Billing for immunohistochemical stains is in addition to standard Mohs layer billing, and is generally billed on a per-specimen basis with code 88342 for the first antibody followed by 88341 for each additional antibody. If multiple separately identifiable antibodies are applied to the slide, use one unit of 88344.

CHAPTER 30 Advanced Techniques and Special Stains in Mohs Micrographic Surgery

INTRODUCTION

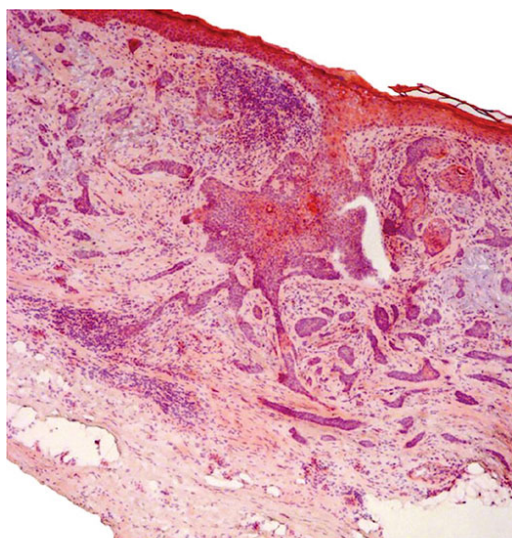
Even in the busiest Mohs micrographic surgery (MMS) practice or at a tertiary/quaternary referral center, special stains are not used on a frequent basis. Treating these cases not only requires a technically proficient micrographic surgeon and laboratory, but also the knowledge of the latest pathology techniques and available immunohistochemistry stains for both permanent and frozen section pathology. While the ability to see 100% of the surgical margin using the MMS technique is certainly an advantage, there are limitations to both this technique and the use of frozen section pathology in certain circumstances. For the specialized tumors discussed in this chapter, both good judgment and an excellent working relationship with a colleague in dermatopathology are a necessity.

ROUTINE STAINS

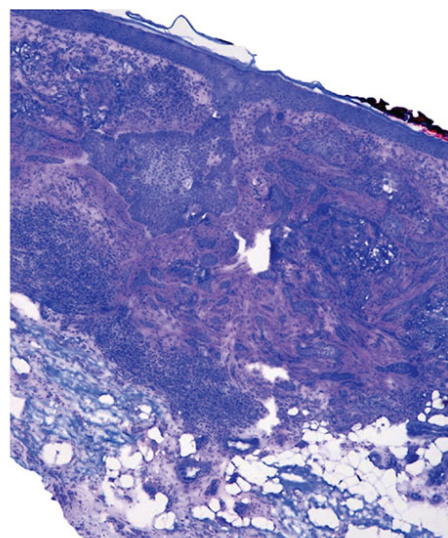
Hematoxylin and eosin (H&E) is the mainstay of MMS staining, and toluidine blue is widely used in certain corners of the MMS community. It is likely that familiarity with the stain leads to high confidence in tumor detection and cure rates with either stain.

Both toluidine blue and H&E have been used from the 1800s and have remained popular in both permanent section pathology and frozen section pathology to the present day. Hematoxylin is derived from the logwood tree (*Haematoxylum campechianum*), native to Central America and the West Indies. It was initially used as a dye and first reported in tissue staining in 1865.¹ Toluidine blue (also known as tolonium chloride) was discovered in 1856 and also used as a dye.² Eosin, the potassium salt of tetrabromofluorescein, was synthesized in 1871,³ and dual staining with H&E was first reported in 1876.⁴

A survey study reported that 17% of Mohs surgeons use toluidine blue for detection of basal cell carcinoma (BCC) in MMS.⁵ Toluidine blue produces characteristic metachromatic staining of the mucopolysaccharides in the stroma of BCC, producing a magenta color (Fig. 30-1). This highlighting of the stroma and BCC draws the eye of the Mohs surgeon. The metachromatic staining in the stroma of BCC allows easy differentiation of basaloid follicular epithelium from BCC. The other advantage of using toluidine blue is a more rapid staining than H&E. A variety of rapid protocols have been published in the literature.^{5,6}



A



B

Figure 30-1. Infiltrative basal cell carcinoma. (A) Staining with hematoxylin and eosin (40×). (B) Staining with toluidine blue of the same tumor; notice, the metachromatic (**magenta**) staining of the associated stroma (40×). (Used with permission from David Zloty, MD).

Some have also argued that toluidine blue is not inferior to H&E staining for the detection of squamous cell carcinoma (SCC),⁷ and the concurrent use of both toluidine blue and H&E may improve diagnostic accuracy in MMS.⁸ Ultimately, familiarity with the stain appears to be the most important driver of tumor detection.

IMMUNOHISTOCHEMICAL STAINS

While recognizing SCC and BCC on frozen sections stained with H&E or toluidine blue is usually straightforward, there are certain situations when it may be difficult to clearly distinguish residual tumor cells, potentially resulting in unnecessary additional layers, or tumor recurrence. Such situations include poorly differentiated tumor cells, dense inflammation, perineural invasion, and fibrosis.^{9,10} These situations are also encountered during the treatment of rarer tumors such as dermatofibrosarcoma protuberans (DFSP) and extramammary Paget's disease (EMPD). It is in these cases of high-risk or difficult tumors that immunostains can be used in addition to routine staining to aid the surgeon in identifying residual tumor.

Immunostaining in MMS was first reported in 1984¹¹ and has since become more reliable, cost effective, and efficient, contributing to its usage nearly doubling in the last 12 years.¹² Immunohistochemistry allows the visualization of specific antigen(s) in tissue using light microscopy. This can be performed using a one-step direct method, or a two-step indirect method. In both the direct and indirect methods, an enzyme conjugated to the primary or secondary antibody, respectively, catalyzes a chromogen, which in turn acts as a stain that can be visualized.¹³ Immunostaining requires a skilled histotechnician, as sections should be 4 µm in thickness or less, due to the potential for thicker sections to hold the stain, increasing nonspecific staining.¹⁰ More rapid immunostaining techniques may also increase background and nonspecific staining, making the use of negative controls necessary.⁹ While multiple antigens may be positive in cutaneous tumors

(Table 30-1), certain immunostains are more useful than others in identifying specific tumor cells.

Table 30-1. Immunostains for Tumors Treated with Mohs Micrographic Surgery^{10,14–17}

Neoplasm	Immunostain	
	Positive	Negative
Squamous cell carcinoma	Cytokeratins (AE1/AE3, MNF116, CK5/6), p63	S100, HMB-45, Melan-A, SMA, desmin, CD10, CD31, CD34
Basal cell carcinoma	Cytokeratins, Ber-EP4	EMA
Dermatofibrosarcoma protuberans	CD34	Cytokeratins, factor XIIIa, S100, desmin, SMA
Extramammary Paget's disease	CK7, CEA, EMA, GCDFP	S-100, Melan-A
Microcystic adnexal carcinoma	AE1/AE3, EMA, CEA	CK20, Ber-Ep4
Sebaceous carcinoma	AE1/AE3, CK7, Cam 5.2, EMA, BER-EP4, adipophilin, androgen receptor	CEA
Atypical fibroxanthoma	CD10, CD68, procollagen-1, alpha-1-antitrypsin	Cytokeratins, p63, CD34, S100, HMB-45, Melan-A, desmin
Merkel cell carcinoma	CK20, MNF116, synaptophysin	TTF-1
Atypical intradermal smooth muscle neoplasms (cutaneous leiomyosarcoma)	SMA, desmin	Cytokeratins, CD34, S100, HMB-45, Melan-A
Porocarcinoma	CEA, EMA, adipophilin, CD117	S-100

SMA, smooth muscle actin; CEA, carcinoembryonic antigen; EMA, epithelial membrane antigen; GCDFP, gross cystic disease fluid protein.

Cytokeratins

Cytokeratins, or simply keratins, are intermediate filaments that play a role in the structural integrity and resilience of the epidermis. They are found in nearly all epithelial cells, but not in nonepithelial cells such as fibroblasts, muscle cells, or neurons,¹⁸ and are therefore useful in identifying tumor cells derived from the epidermis.¹⁰ Cytokeratins are classified by their molecular weight or pH. Low-molecular-weight cytokeratins include CK7, 8, 18, 19, and 20, while CK1, 2, 5, 9, 10, and 14–17 are high-molecular-weight cytokeratins. Type I (acidic) cytokeratins include CK9–19 and type II (basic) group is composed of CK1–8. Glandular epithelium is composed of low-to intermediate-molecular-weight keratins, and squamous epithelium of primarily high-molecular-weight keratins.¹³

AE1/AE3 is a pankeratin stain that recognizes cytokeratins between 40 and 67kDa in molecular weight. The AE1 antibody binds to CK10, 14–16, and 19, while AE3 binds to CK1–8.¹⁸ SCC expresses CK5, 6, 8, 14, 17, and 18, while BCC expresses CK5, 14, 15, and 17.¹³ The AE1/AE3 cocktail will thus stain most SCCs and BCCs and can be useful in cases where there is residual tumor in areas of heavy inflammation (Fig. 30-2), perineural spread

(Fig. 30-3), or extension into fascia.^{19,20} AE1/AE3 is also an effective choice for staining microcytic adnexal carcinoma (MAC) and sebaceous carcinoma.¹⁴

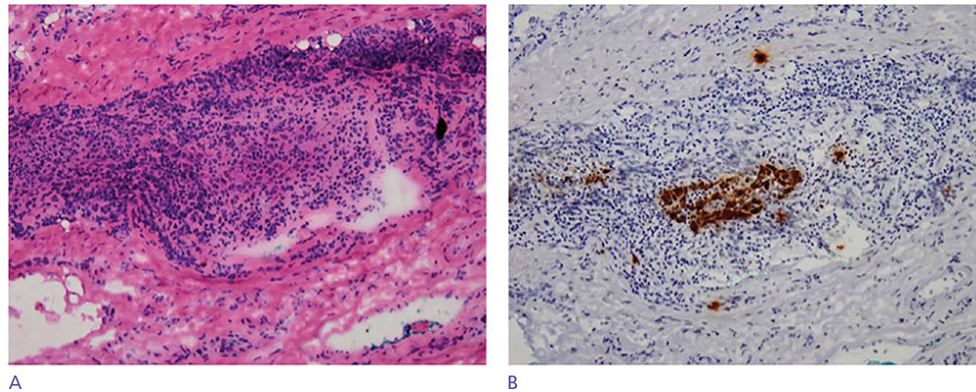


Figure 30-2. Squamous cell carcinoma with dense inflammation (400×). (A) Hematoxylin and eosin. (B) AE1/AE3 stain demonstrates carcinoma cells within inflammation. (Used with permission from Thuzar M. Shin, MD, PhD).

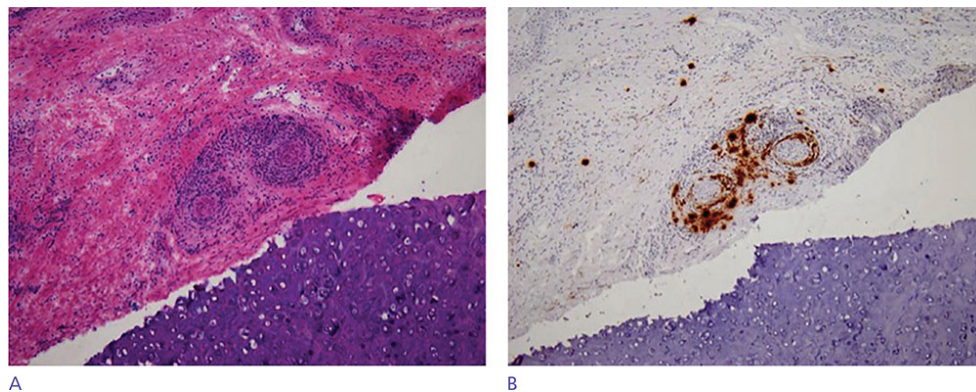


Figure 30-3. Squamous cell carcinoma with perineural invasion (100×). (A) Hematoxylin and eosin. (B) AE1/AE3 stain makes perineural tumor cells much more easily identifiable. (Used with permission from Thuzar M. Shin, MD, PhD).

MNF116 is a monoclonal antibody that detects both low- and high-molecular-weight cytokeratins (CK5, 6, 8, 17, and 19). It shows cytoplasmic staining and is positive in all cutaneous lesions with epithelial differentiation including SCC, BCC, adnexal tumors, and Merkel cell carcinoma (MCC).²¹ MNF116, particularly in combination with p63, may be a sensitive stain for poorly differentiated SCC.²²

CK7 is a low-molecular-weight cytokeratin and is a specific, intense stain for Paget cells as well as the immunostain of choice for EMPD.²³ Sebaceous carcinoma may also express CK7.²⁴

Cam 5.2 stains for the low-molecular-weight cytokeratin CK8, and to a lesser extent, CK7.²⁵ It can be very useful in identifying sebaceous carcinoma and distinguishing it from benign sebaceous neoplasms, SCC, and BCC.²⁶ Cam 5.2 staining is also positive in primary cutaneous mucinous carcinomas.¹⁴

CK20 is a low-molecular-weight cytokeratin and is frequently used in the diagnosis of MCC.

Ber-EP4

Ber-EP4 is a monoclonal antibody against human epithelial antigen and binds a glycopolypeptide on the surface and within the cytoplasm of epithelial cells.¹⁴ Ber-EP4 is useful in differentiating BCC from SCC, and although the antigen is found in adnexal structures such as apocrine and eccrine glands, aside from the base of the hair bulb, Ber-EP4 is generally absent in hair follicles, making it useful in differentiating BCC from hair follicles.²⁷ Ber-EP4 can be helpful in identifying BCC tumor cells in difficult cases where there is dense inflammation, perineural disease, or an infiltrative component.²⁸

CD10

CD10, also known as the common acute lymphoblastic leukemia antigen (CALLA), is a cell-surface glycoprotein found on hematopoietic progenitor cells and nonhematopoietic cells.¹⁶ Strong and diffuse staining of atypical fibroxanthoma (AFX), including perifollicular extension, has been demonstrated with CD10.^{16,29} However, spindle-cell SCCs can also stain strongly for CD10. These tumors can be differentiated with additional immunostains, as SCC should be positive for cytokeratins and p63.¹⁶

CD34

CD34 is a transmembrane glycoprotein found on dermal dendritic cells, as well as endothelial and hematopoietic progenitor cells.^{30,31} It is commonly used to differentiate DFSP from other fibrous tumors, particularly dermatofibroma, but also AFX, fibrosarcoma, and nodular fasciitis.³² It has been useful in the treatment of DFSP with MMS, as tumoral spindle cells can be difficult to distinguish from normal fibroblasts.³¹

Carcinoembryonic antigen

Carcinoembryonic antigen (CEA) encompasses a set of glycoproteins involved in cell adhesion. CEA levels are elevated in various malignancies, making it useful as a tumor marker for select cutaneous malignancies. CEA has been shown to identify ductal structures in MAC.³³ Paget cells can have variable staining with CEA, but it can be useful in distinguishing EMPD from adjacent intraepidermal dysplasia.³⁴ CEA also labels eccrine and apocrine cells which can be used as an internal control.¹³

Epithelial membrane antigen

Epithelial membrane antigen (EMA) is a glycoprotein expressed on secretory epithelia. EMA can highlight epithelial cells and ductal structures in MAC.³³ EMA is positive in sebaceous carcinoma, but can also be positive in SCC, and is therefore not as useful a stain as Cam 5.2 for sebaceous carcinoma.²⁶ EMA may also stain Paget cells.¹⁵

Adipophilin

Adipophilin, also known as adipose differentiation-related protein or perilipin 2, is a protein required for the formation and maintenance of lipid droplets. Although its expression is nearly ubiquitous, it has been reported to be a sensitive marker for sebaceous carcinoma.^{24,35} Adipophilin expression is also seen in a variety of other tumors including SCC with clear cell change, eccrine–apocrine carcinomas,³⁵ and malignant melanoma,³⁶ indicating that lipids are necessary for cellular proliferation with a possible correlation between the expression of adipophilin and the proliferative

potential of cancer cells.³⁶ Although other cutaneous malignancies may express adipophilin, a globular staining pattern, as typically expressed in cells with sebaceous differentiation, may be more specific for sebaceous carcinoma. SCC, sweat gland (eccrine and apocrine) carcinomas, and malignant melanoma tend to have more granular staining.^{35,36}

p63

p63 is a member of the *p53* gene family and may play an essential role in regulating the development and differentiation of the epidermis. It is a nuclear marker expressed in the epidermis, eccrine ducts, sebaceous glands, and myoepithelial cells of the eccrine and apocrine glands.³⁷ p63 is overexpressed in SCC and is therefore thought to act as an oncogene.³⁷ p63 staining can be useful in differentiating spindle-cell SCC from other spindle-cell neoplasms such as AFX and melanoma.^{16,22,37}

RARE TUMORS TREATED WITH MOHS MICROGRAPHIC SURGERY

MMS is most frequently utilized in the treatment of SCC and BCC, as these are the most common cutaneous malignancies. However, there are other tumors for which MMS is an appropriate therapy. A multidisciplinary approach to rare cutaneous tumors may result in the best outcomes for patients.

Dermatofibrosarcoma protuberans

DFSP is a slow-growing, locally aggressive soft tissue tumor with an incidence of 4.2 per million (0.1% of all cancers).³⁸ There is a higher incidence in African Americans.³² DFSP occurs most frequently on the trunk, followed by the proximal extremities, and then the head and neck.³² Histopathologically, DFSP appears as a proliferation of spindle cells in the dermis with projections that can extend into neighboring collagen bundles and underlying fat, as well as muscle and fascia (Fig. 30-4). These

extensions can make complete removal difficult, with recurrence rates as high as 60% reported after wide local excision (WLE).³² While the overall recurrence rate after WLE may be closer to 7.3%, there is currently no consensus regarding the most appropriate surgical margin,³² with 5-cm margins potentially leaving residual tumor in 5.2% of cases.³⁹ Uncertainty regarding adequate margins and high recurrence rates, particularly of tumors located on the head and neck, led to the utilization of MMS in the treatment of DFSP, where recurrence rates ranging from 0% to 6.6% have been reported.⁴⁰ In a recent study, DFSP treated with MMS was nine times less likely to have recurrence compared with those treated with WLE.⁴¹ Surgeons and patients should be aware that the defect size is often much larger than the original lesion, with a defect to lesion size ratio of 7.7 reported in one report (Fig. 30-5).⁴⁰

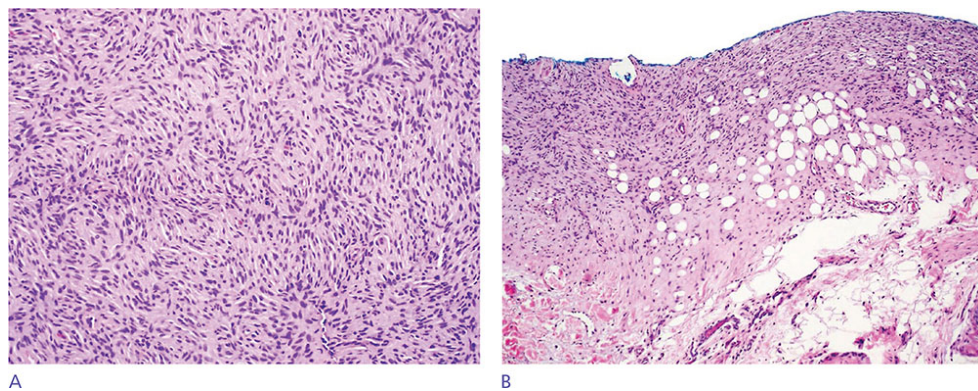


Figure 30-4. Dermatofibrosarcoma protuberans. Hematoxylin and eosin. (A) Spindle cells in the dermis (200×). (B) Projections into underlying fat leading to honeycombing (100×).

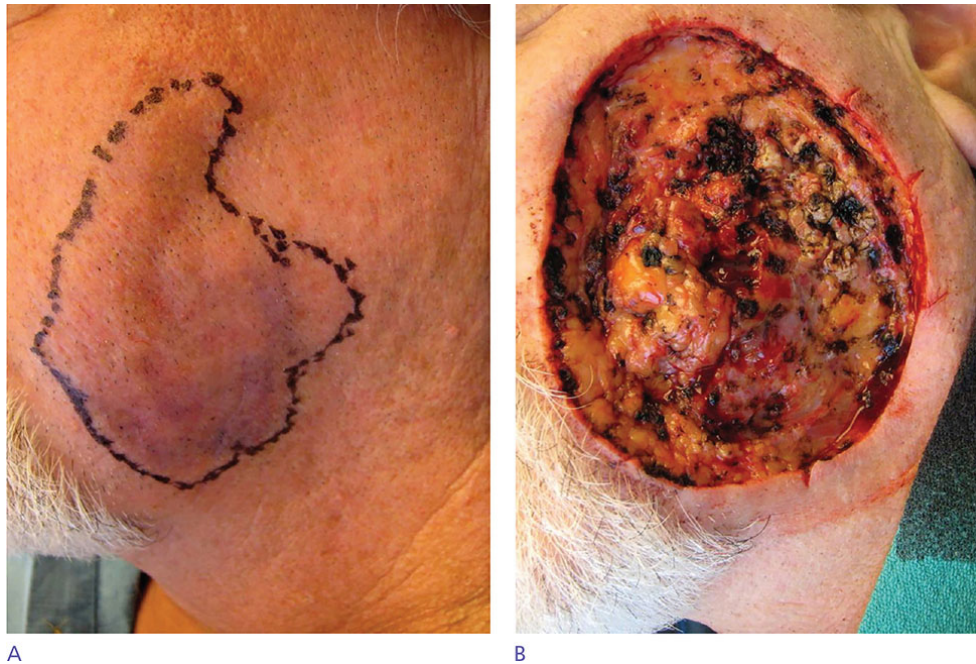


Figure 30-5. Dermatofibrosarcoma protuberans. (A) DFSP on the cheek prior to undergoing Mohs micrographic surgery. (B) Mohs defect; note the increase in size compared to the clinical lesion.

CD34 immunostaining can be used to differentiate DFSP from other fibrous tumors (Fig. 30-6). It may also be useful in determining clear margins during the treatment of DFSP with MMS, particularly in cases where there are areas of scarring.³¹ While CD34 is a valuable stain in DFSP, there can be variable staining in these tumors,³⁰ with negative staining sometimes seen in the nodular portions of DFSP.¹⁴ Nonetheless, CD34 remains the most practical immunostain to be used in MMS for DFSP.¹⁴

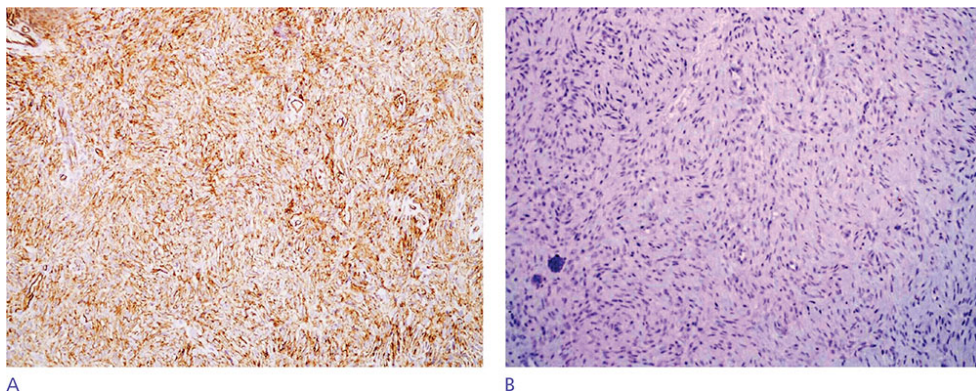


Figure 30-6. Dermatofibrosarcoma protuberans (200×). (A) Positive CD34 staining can help differentiate these tumors from other spindle-cell neoplasms. (B) Negative factor XIIIa staining helps to

differentiate DFSP from dermatofibroma.

Extramammary Paget's disease

EMPD is a rare, slow-growing cutaneous adenocarcinoma that most commonly involves the female genitalia, particularly the vulva. In males, EMPD tends to involve the scrotum, with the penis and pubis involved less frequently.⁴⁰ Other areas of involvement include the perineum, axilla, and umbilicus.¹⁵ Clinically, EMPD presents as an ill-defined erythematous plaque (Fig. 30-7). Histopathologically, EMPD is characterized by large cells with abundant pale-staining cytoplasm (Paget cells) that may be found in clusters abutting the basal layer, as well as scattered upwards throughout the epidermis (pagetoid spread) (Fig. 30-8). The ill-defined clinical margins, along with microscopic extensions of tumor cells, can make complete excision of EMPD difficult, with no consensus on the most appropriate surgical margin. Recurrence rates of 20% to 60% have been reported following WLE.⁴² The utilization of MMS for EMPD has resulted in lower rates of recurrence, with reports ranging from 0% to 27%.⁴⁰ A systematic review and meta-analysis showed an overall EMPD recurrence rate of 12.2% following MMS.⁴² A defect to lesion size ratio of 3.2 has been reported.⁴⁰



Figure 30-7. Extramammary Paget disease presents as an ill-defined erythematous plaque. (Used with permission from Ali Hendi, MD).

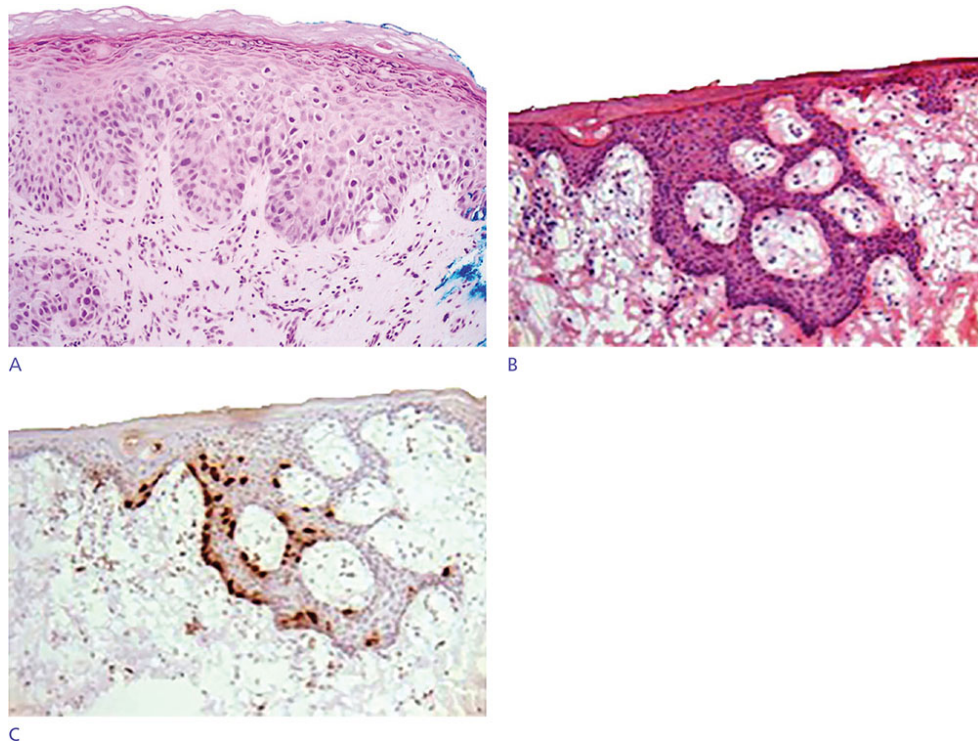


Figure 30-8. Extramammary Paget's disease. (A) Hematoxylin and eosin stain demonstrates malignant Paget cells (200×). (B) Hematoxylin and eosin (100×). (C) Immunohistochemical stain for CK7. (B,C used with permission from Ali Hendi, MD).

Immunostains are important in the diagnosis of EMPD on permanent sections and can also be used on frozen sections during MMS. Paget's cells may stain with CK7, CEA, EMA, and gross cystic disease fluid protein (GCDFP). Of these stains, CK7 is the most sensitive and intense, and is therefore the immunostain of choice in the diagnosis of EMPD (Fig. 30-8).²³ CK7 has been used in the treatment of EMPD with MMS, but its effect on recurrence rate has not yet been published.¹⁵

Microcystic adnexal carcinoma

Microcystic adnexal carcinoma (MAC), also known as malignant syringoma or syringoid carcinoma, is another rare cutaneous tumor. MAC tends to occur on the central face of Caucasian individuals in the fourth to sixth decades.

Although asymptomatic with indolent growth, rare metastasis, and high survival rates, MAC can be locally aggressive and cause significant morbidity.⁴³ Histopathologically, MAC appears as multiple groups of basaloid epithelial cells, ductal structures, and keratinizing cysts, often infiltrating the superficial and deep dermis as strands of tumor woven through collagen bundles (Fig. 30-9).⁴⁴ Mitoses and cytologic atypia are not a predominant feature.⁴⁵ MMS has proven superior to WLE in treating MAC. Recurrence rates following WLE can range from 17% to 60%, while those after MMS range from 0% to 12%.⁴⁶ As with DFSP, the defect size is often much larger than what is clinically apparent, with a defect to lesion size ratio of 6.2 reported.⁴⁰

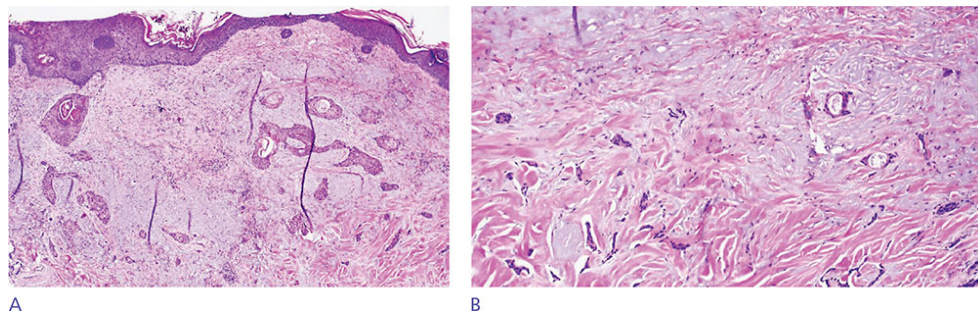


Figure 30-9. Microcystic adnexal carcinoma. (A) Low power demonstrating infiltrative nature of the tumor with syringoma-like structures and keratinaceous microcysts (H&E, 40×). (B) Small infiltrative strands of epithelial structures in the deeper portion of the tumor (H&E, 100×).

Immunohistochemistry can be vital in differentiating MAC from other neoplasms. CEA, EMA, and AE1/AE3 are most helpful in differentiating eccrine and pilar derivatives of MAC.^{14,33}

Sebaceous carcinoma

Sebaceous carcinoma is a rare, and sometimes, aggressive cutaneous tumor found most commonly in the periocular region (Fig. 30-10), representing 1% to 6.4% of all eyelid malignancies.⁴⁷ There is a higher frequency of sebaceous carcinoma in patients with Muir–Torre syndrome (MTS), a rare, autosomal dominant genodermatosis.⁴⁸ Histopathologically, sebaceous carcinomas appear as foamy cells with sebaceous differentiation (Fig. 30-11). Cellular atypia and mitotic figures are common, and pagetoid spread

may be seen. These tumors most commonly grow by direct extension and tissue invasion, but there may be multifocal growth with skip areas leading to margin involvement, and local recurrence rates of up to 36% following WLE with 5- to 6-mm margins have been reported.¹⁴ Treatment of sebaceous carcinoma with MMS can have better outcomes, with recurrence rates of 12% or less.⁴⁷ A defect to lesion size ratio of 4.7 has been reported following MMS.⁴⁰



Figure 30-10. Sebaceous carcinoma presenting as a yellowish erythematous papule on the upper eyelid. (Used with permission from Eva Hurst, MD).

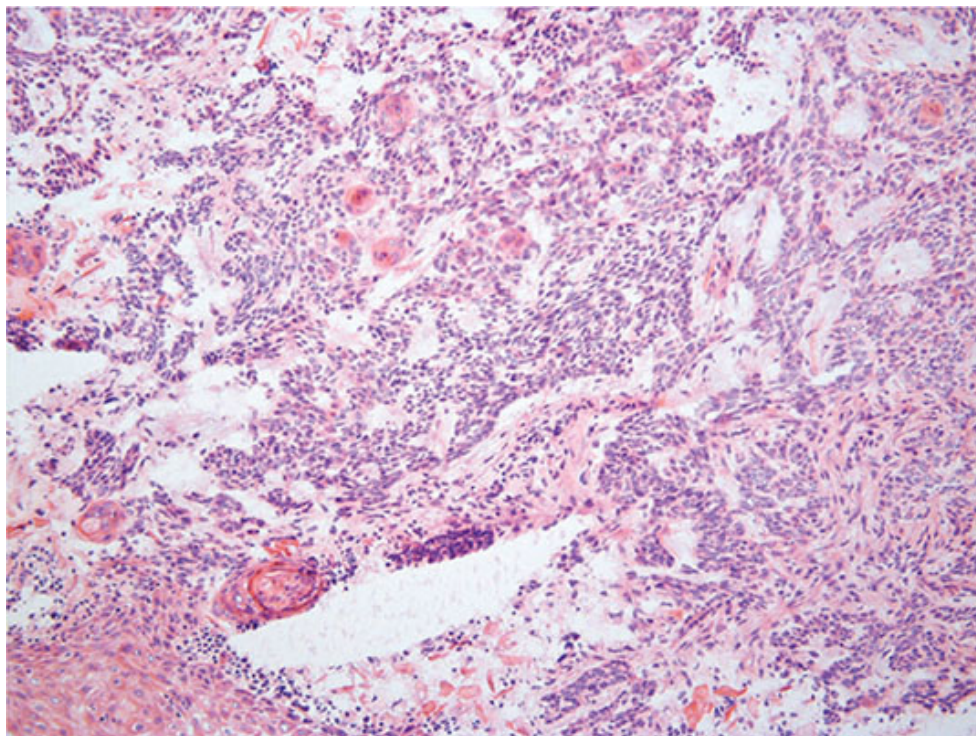


Figure 30-11. Sebaceous carcinoma is characterized by foamy cells with sebaceous differentiation (H&E, 200×). (Used with permission from Eva Hurst, MD).

Immunohistochemistry can play a variety of roles in sebaceous carcinomas. Due to the association with MTS, immunostains for germline mutations in MLH1 (Fig. 30-12), MSH2, MSH6, and PMS2 (Fig. 30-12) may prove useful in some, as the loss of staining of these mismatch repair genes has a high positive predictive value for MTS.⁴⁸ AE1/AE3, EMA, CK7, cam 5.2, and adipophilin are positive in sebaceous carcinomas and can be useful in detecting intraepithelial spread, including nests and single-cell spread. Of these stains, cam 5.2 has the highest specificity for sebaceous carcinomas and can be used to differentiate these tumors from benign sebaceous neoplasms, as well as SCC and BCC.¹⁴ While EMA and adipophilin may have high sensitivity for sebaceous carcinoma,²⁴ SCC may also express these proteins, thus decreasing their specificity.

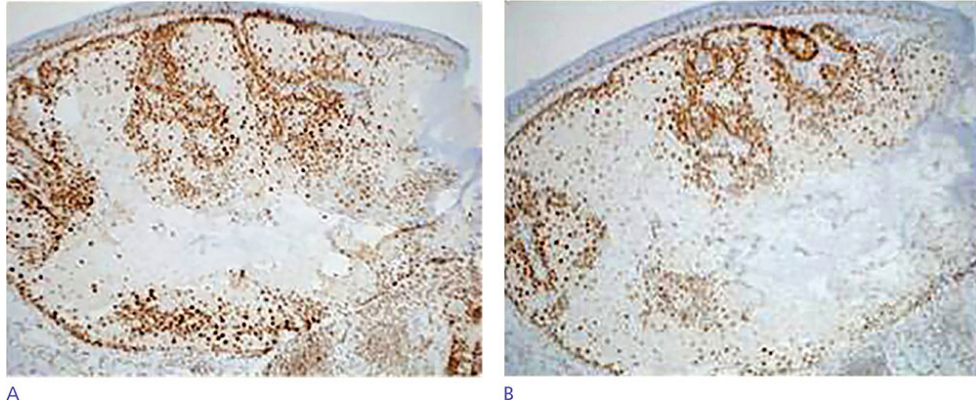


Figure 30-12. Sebaceous carcinoma (40×). (A) MLH1. (B) PMS2. (Used with permission from Eva Hurst, MD).

Atypical fibroxanthoma

AFX is an uncommon, superficial fibrohistiocytic tumor with an unknown exact incidence, but in one study made up 0.24% of skin cancers treated with MMS.⁴⁹ These tumors are most commonly found on the scalp (Fig. 30-13), face, and neck of elderly Caucasian men.⁵⁰ Risk factors include UV exposure, radiation therapy, and immune dysregulation.⁵¹ Histopathologically, AFX most commonly appears as pleomorphic spindle, epithelioid, and multinucleated giant cells with numerous mitotic figures and nuclear pleomorphism (Fig. 30-14).^{50,52}



Figure 30-13. Atypical fibroxanthoma presenting as a large red nodule on the frontal scalp. (Used with permission from S. Tyler Hollmig, MD).

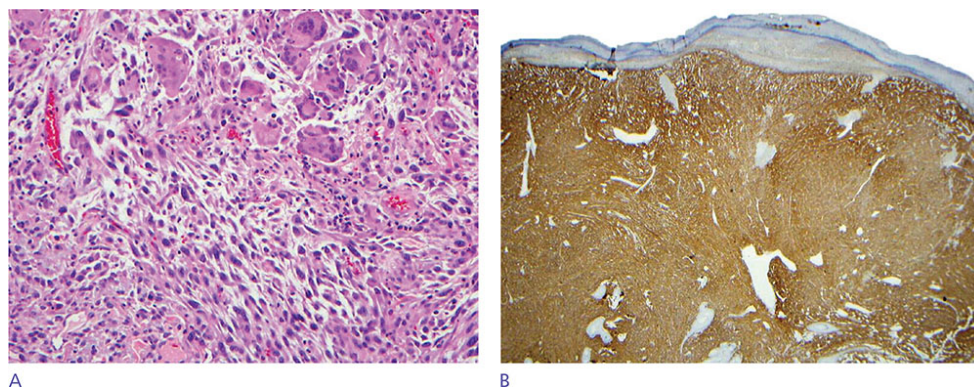


Figure 30-14. Atypical fibroxanthoma. (A) Hematoxylin and eosin staining shows pleomorphic spindle and epithelioid cells with giant cells (200×). (B) Strong and diffuse staining with CD10 (40×). (Used with permission from S. Tyler Hollmig, MD).

Despite these malignant features and its consideration as a pleomorphic dermal neoplasm, AFX is characterized by indolent clinical behavior and rare metastasis.^{50–53} This is in contrast to undifferentiated pleomorphic sarcoma (UPS) which has a higher rate of metastasis and poor outcomes. AFX remains a diagnosis of exclusion and, unfortunately, does not have any concrete discriminatory histologic or immunohistochemical features to differentiate it from UPS.⁵³ Certain features, including larger tumor size (>2 cm), tumor necrosis, increased depth with tumor involving subcutaneous tissue and fascia, and vascular or neural involvement, may be more suggestive of UPS.^{54–56} Given the similarities and differences, AFX is viewed by some to be a superficial variant of UPS.⁵⁷ Adding to the confusion is the use of the term pleomorphic dermal sarcoma (PDS) in the literature, and the replacement of the old term malignant fibrous histiocytoma (MFH) with UPS. It should be noted that UPS, PDS, and MFH are synonymous, with the term UPS now being preferred.

WLE with 2-cm margins is necessary to clear 96.6% of tumors, leading to an increase in the use of MMS in the treatment of AFX.⁵⁷ Recurrence rates following WLE have been reported to range from 2% to 21%, while those following MMS range from 0 to 6.9%.^{57,58} In a study of 2960 patients, there was no significant difference in the recurrence and survival rates following WLE versus MMS.⁵⁹

It can be difficult to distinguish AFX from other spindle-cell neoplasms including spindle-cell SCC and melanoma, making immunostains particularly

helpful in the initial diagnosis. In an extensive review of AFX cases, 90% had negative staining for cytokeratins, S100, desmin, and HMB-45.⁵⁹ CD10 has been described as a specific stain for AFX (Fig. 30-14). However, some SCCs can also have strong CD10 staining. AFX can be differentiated from spindle-cell SCC as the latter will be positive for cytokeratins and p63.¹⁶ Negative CD34 and S100 staining in AFX can help differentiate them from DFSP and melanoma, respectively.

Merkel cell carcinoma

MCC is a rare, aggressive cutaneous neoplasm most commonly occurring on the head and neck of elderly Caucasian individuals (Fig. 30-15). Histopathologically, MCC is composed of small blue cells in sheets, nests, or in a trabecular array (Fig. 30-16). MCC can exhibit extensive vertical growth extending to the muscle or fascia, making complete excision with WLE difficult, with recurrence rates of 32% to 50% reported.⁶⁰ As with other rare tumors, recurrence rates with MMS are lower with rates of 0% to 5% reported.^{40,60} Given its radiosensitivity, adjuvant radiation therapy following MMS is a consideration.⁶⁰ Additionally, due to the high rate of metastasis, sentinel lymph node biopsy may be performed in patients without clinical or radiological evidence of nodal disease.⁶¹ A defect to lesion size ratio of 4.5 has been reported.⁴⁰



Figure 30-15. Merkel cell carcinoma presenting as a red papule on the right ala.

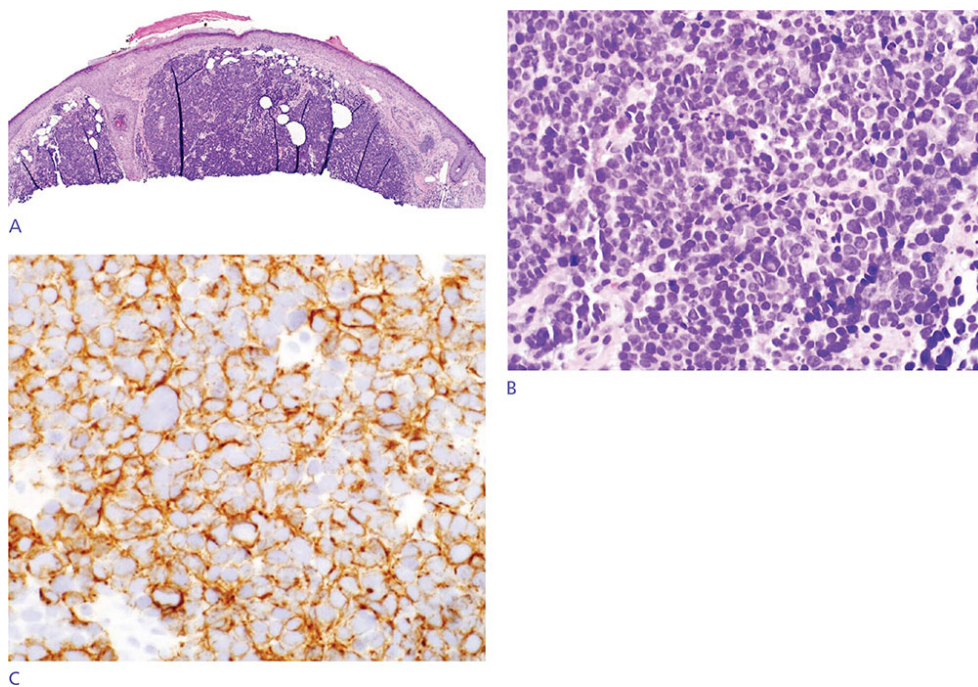


Figure 30-16. Merkel cell carcinoma. (A) Hematoxylin and eosin demonstrating small atypical blue cells that are primarily nested (40×). (B) “Salt and pepper” chromatin and atypical cells (hematoxylin

and eosin, 400×). (C) CK20 labeling carcinoma in a characteristic perinuclear dot pattern (400×).

Immunostaining with CK20 is often used to confirm the diagnosis of MCC.¹⁴ CK20 has a characteristic “dot-like” perinuclear staining pattern (Fig. 30-16). A similar staining pattern is seen with MNF116.²¹ Synaptophysin can be used for confirmation in cases that do not have this characteristic staining pattern.⁶² Because MCC is typically easily visualized on frozen section, immunostains during MMS tend to be unnecessary.⁶⁰

Atypical intradermal smooth muscle neoplasms (cutaneous leiomyosarcoma)

Atypical intradermal smooth muscle neoplasms (AISMN), also known as cutaneous leiomyosarcoma (LMS), are rare soft-tissue malignancies, with approximately 400 cases reported in the literature.⁶³ AISMN arises from the arrector pili muscle, while subcutaneous LMS arises from smooth muscle of the blood vessels in the subcutaneous tissue. Both are found most commonly on the extremities, but can occur elsewhere including on the face (Fig. 30-17).⁶⁴ Histopathologically, AISMN and subcutaneous LMS are characterized by hypercellular, intertwined muscle fascicles with variable mitoses (Fig. 30-18). AISMN can be aggressive, but has a lower rate of metastasis than subcutaneous LMS.⁶⁴ For some, the term AISMN has supplanted cutaneous LMS in the nomenclature, as neoplasms confined to the dermis have been found to have a very low rate of metastasis and thus should not be referred to as a sarcoma.^{65,66} However, others feel that although AISMN does recur and metastasize less frequently than its deeper counterparts, it has been implicated in causing death, and thus both should be referred to as LMS.⁶⁷



Figure 30-17. Atypical intradermal smooth muscle neoplasm presenting as an erythematous keratotic papule on the right lower vermilion and cutaneous lip.

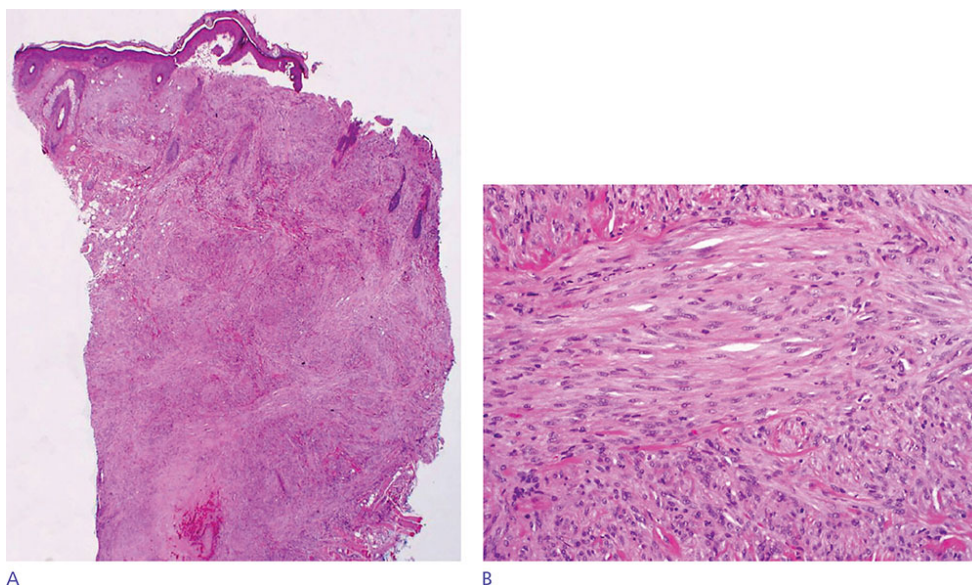


Figure 30-18. Atypical intradermal smooth muscle neoplasm. Hematoxylin and eosin stain shows an atypical spindle-cell proliferation. (A) 20×. (B) 200×.

The standard of care for AISMN has been WLE, although no consensus has been made regarding the most appropriate surgical margins.⁶⁸ Recurrence rates are the highest in cases where less than a 1-cm margin is taken, and have been reported to be as high as 67%.^{64,65} Positive margin status may be the strongest predictor of recurrence.⁶⁶ MMS is being used more frequently in the treatment of LMS, with a recurrence rate of approximately 5%.⁶⁴

AISMN and subcutaneous LMS have a histologic appearance similar to other spindle-cell neoplasms, and immunostains are often necessary to make the diagnosis. These tumors show positive staining for smooth muscle actin (Fig. 30-19) with approximately 60% of tumors also staining positively for desmin.⁶⁹ CD34, S100, and CK5/6 are negative helping to distinguish AISMN and subcutaneous LMS from other spindle-cell tumors.⁶⁶ One case series showed a loss of phosphatase and tensin homolog (PTEN) staining in the majority of cases examined, possibly suggesting that there is a loss of PTEN expression during the development of AISMN.⁶⁶

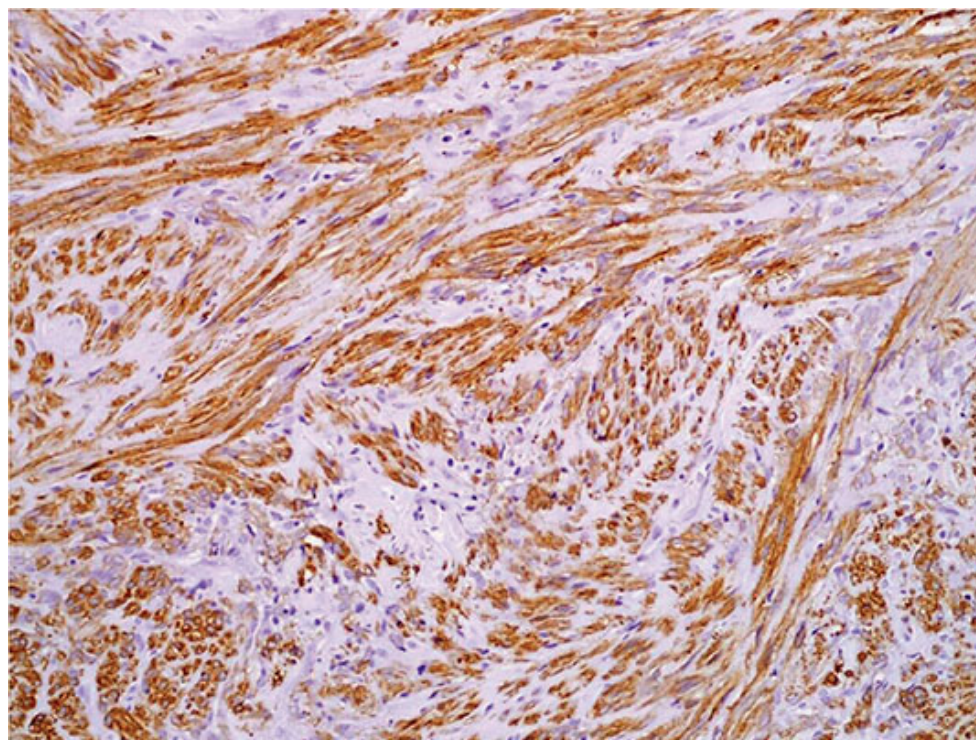


Figure 30-19. Atypical intradermal smooth muscle neoplasm staining with smooth muscle actin (200×).

Eccrine porocarcinoma

Eccrine porocarcinoma (EPC), also known as malignant eccrine poroma, is a rare cutaneous tumor arising from the acrosyringium, the intraepidermal portion of the eccrine duct. EPC represent 0.005% of all malignant epithelial neoplasms.⁷⁰ Initially, EPC is a slow-growing lesion, but then enters a proliferative, vertical growth phase with a propensity to metastasize to regional nodes. Histopathologically, EPC is characterized by intraepidermal clusters of small, basaloid malignant cells (Fig. 30-20). Dermal invasion occurs, with broad anastomosing columns of tumor cells penetrating to varying levels of the dermis.⁷¹ Foci of squamous differentiation and melanin pigment may be present, but the presence of ductal structures can be helpful in making the diagnosis. Pagetoid spread is not a feature of EPC. Cells are rich in glycogen and thus appear clear, and are periodic acid-Schiff positive and diastase labile.⁷¹ WLE has been associated with recurrence rates of 20%, and rates of distant metastasis and death of approximately 11%.⁷² MMS has been shown to have lower rates of recurrence, and thus may offer superior outcomes compared to WLE.^{73,74}

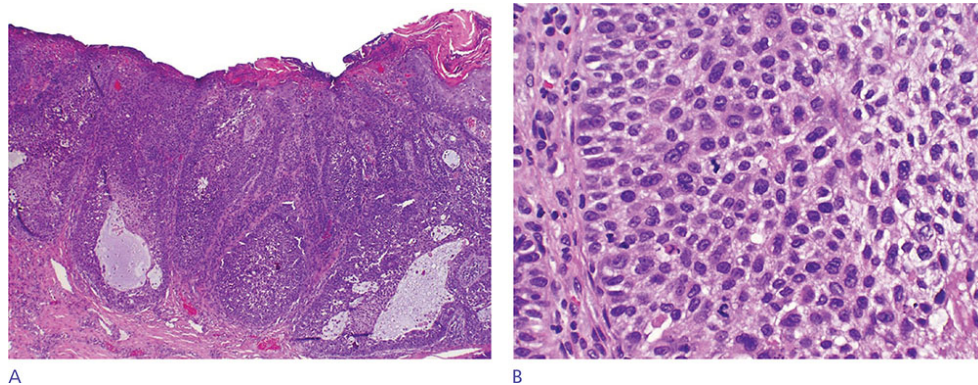


Figure 30-20. Eccrine porocarcinoma. (A) Marked hyperplasia of the epidermis with intraepidermal clusters of pleomorphic cells and large ducts (H&E, 40×). (B) Small, poroid cells with prominent mitotic and apoptotic small ductules (H&E, 400×).

Distinguishing EPC from other entities with similar histopathological findings such as Bowen's disease, EMPD, and melanoma in situ, can be difficult, and immunostains may be necessary. EPC stains positively for CEA and EMA.⁷¹ CD117 (c-kit) may also be positive in EPC and help in the

differentiation from SCC, most of which stain negatively for CD117.⁷⁵ EPC may also stain with adipophilin.³⁵

Dermatofibrosarcoma Protuberans

A 39-year-old male was seen in the outpatient dermatology clinic for a “lump” present in his scalp for 1 month (Fig. 30-21). The clinical differential diagnosis included a pilar cyst versus lipoma. A punch biopsy was performed and demonstrated a proliferation of wavy and spindle-shaped cells arranged in short fascicles with focal arrangement in a storiform pattern. The cells infiltrated the fat in parallel bands and sometimes in a “honey-comb” pattern. The lesional cells demonstrated immunoreactivity with CD34 and did not label with factor XIIIa or S-100. The findings were consistent with a DFSP.



Figure 30-21. Dermatofibrosarcoma protuberans presenting as a subcutaneous nodule on the posterior scalp.

The patient was referred to the dermatologic surgery service and MMS was recommended. The initial clinical lesion was 3.0 cm × 2.2 cm. After

five stages of MMS, there continued to be positive lateral and deep margins with a defect of 8.0 cm × 6.5 cm. Due to approaching maximum lidocaine dose, patient fatigue, and anxiety, it was decided to resume surgery the following day where an additional 2-cm margin was resected along with deep galeal and periosteal tissue which was submitted for permanent sections (Fig. 30-22). Permanent sections processed en face failed to reveal tumor at the margins. The defect was reconstructed in the operating room with multiple rotation flaps. The patient remains tumor free 3.5 years after initial presentation.



Figure 30-22. Mohs map and resection of final 2-cm margin of a large dermatofibrosarcoma protuberans on the scalp. Margin, galea, and periosteum submitted for permanent sections.

This case exemplifies a multidisciplinary approach and use of all the tools at hand to clear these tumors. MMS is a tissue-sparing procedure and was the appropriate choice in this situation even given the positive

margins and need for later resection. An initial excision with as much as 2- to 3-cm margins still would have resulted in positive margins and the need for further resection. The tumor ultimately required a greater than 7-cm margin for tumor clearance (Fig. 30-23).

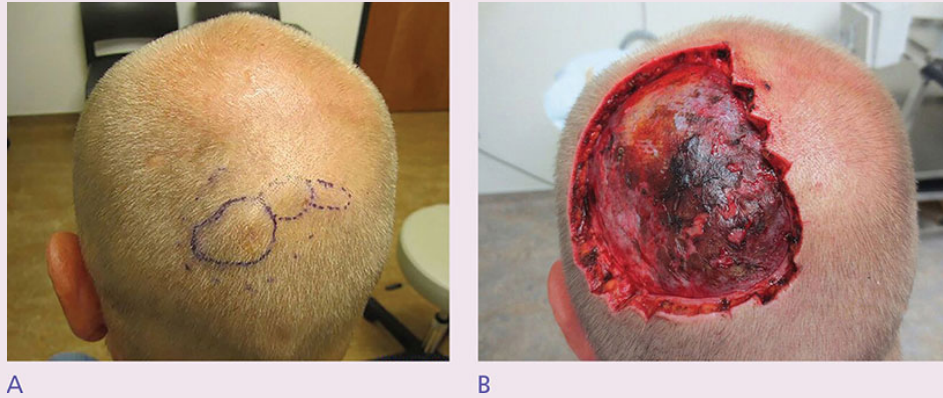


Figure 30-23. Dermatofibrosarcoma protuberans. (A) Preoperative photograph of Mohs site. (B) Postoperative defect.

The use of CD34 stains on frozen sections is fraught with difficulty. The CD34 stain is a difficult stain to interpret under the best of circumstances on paraffin-embedded tissue. CD34 labels endothelial cells and has a tendency to nonspecifically stain soft tissue. It is not recommended as a stain for frozen section diagnostic pathology. The cells of DFSP are usually readily identified in tissue without the need for an immunohistochemical stain. The immunohistochemical stain is most valuable in making the diagnosis or in situations where the Mohs surgeon is not certain regarding the margins and needs to submit paraffin embedded tissue for confirmation.

It is crucial to perform the correct surgery the first time. These cases can be very challenging, as patients that are partially resected or those that are resected and closed with positive margins may be difficult to treat. In these cases, slide interpretation is fraught with problems, and CD34 immunohistochemical staining is very challenging given the inflammatory milieu and numerous other inflammatory cells in the tissue.

Periosteum can be resected with the overlying tissue or by itself if there is a positive margin noted on the periosteal tissue. It is preferable from a reconstructive standpoint if periosteum is not sacrificed, and it

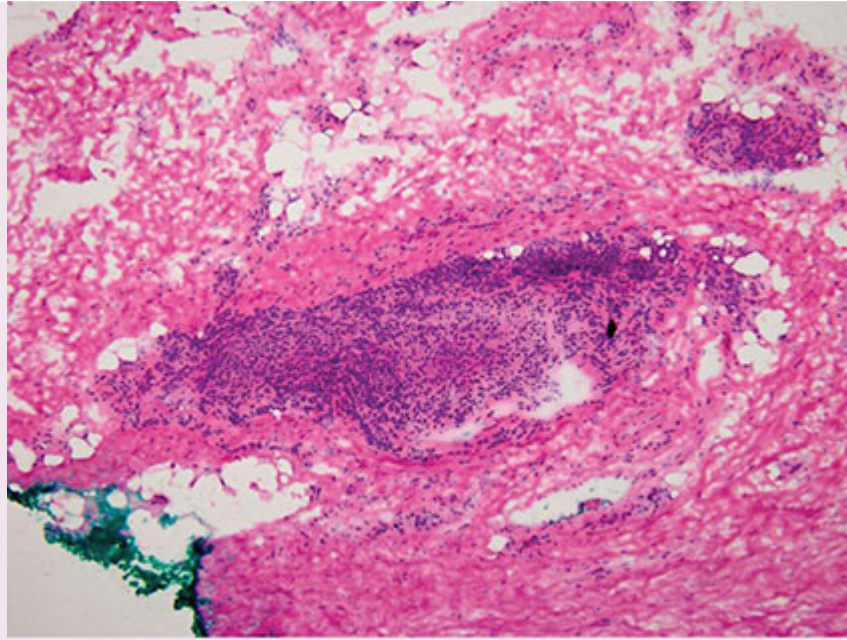
should be spared if possible. It may be ideal to submit periosteal tissue to the pathology lab. A detailed map is made and the periosteum is usually bread-loafed after fixation. Other Mohs surgeons prefer to process this tissue with frozen sections. This is delicate tissue and requires proper handling in either circumstance.

Squamous Cell Carcinoma with Perineural Invasion

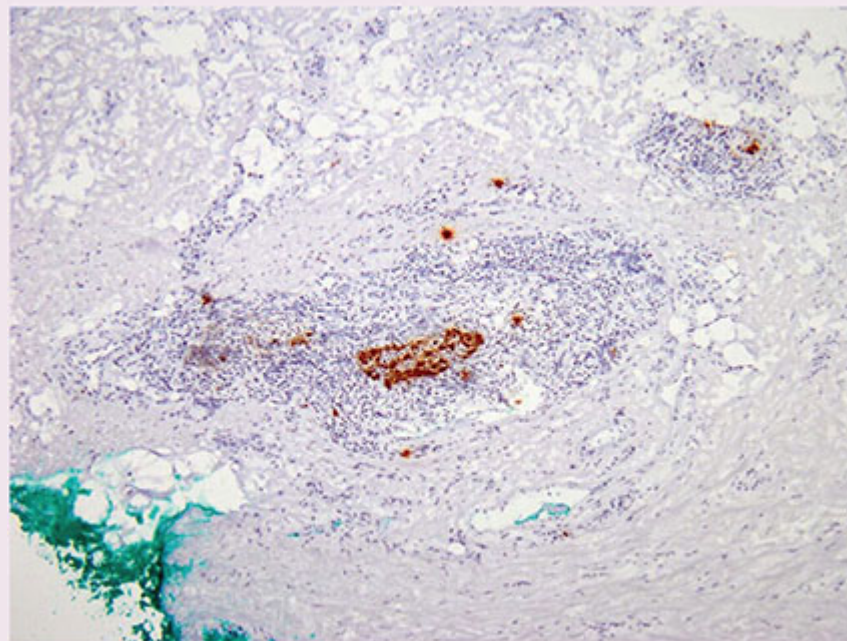
An 86-year-old male presented with a pruritic nonpainful lesion in the ear that, per the patient, had been present for several months ([Fig. 30-24](#)). On examination, there was a 2-cm ulcerated erythematous plaque in the right conchal bowl. MMS was performed and revealed poorly differentiated SCC with prominent perineural invasion. Examination of the debulk tissue specimen showed perineural SCC involvement of a small 0.04-mm-diameter nerve. AE1/AE3 staining was used to highlight tumor on the first two stages ([Fig. 30-25](#)). Four stages were required to clear the tumor, resulting in a defect spanning the conchal bowl ([Fig. 30-26](#)).



Figure 30-24. Invasive squamous cell carcinoma of the right conchal cavity.



A



B

Figure 30-25. Mohs layer of invasive squamous cell carcinoma. (A) Hematoxylin and eosin staining shows tumor cells admixed with inflammatory cells (100×). (B) AE1/AE3 helps to highlight the tumor cells (100×).



Figure 30-26. Defect after four stages of Mohs micrographic surgery for an invasive squamous cell carcinoma.

This case exemplifies the usefulness of cytokeratin stains in highly inflamed tissue to detect occult SCC. Heavy inflammation, particularly around nerves, is very concerning in patients with large and/or poorly differentiated SCC. This case demonstrates the ability to use frozen section immunohistochemistry to detect these occult invasive carcinomas. For surgeons who lack the ability to perform these stains intraoperatively, they can be used in formalin-fixed paraffin-embedded tissue. This particular tumor can be successfully treated in a number of different ways, with or without frozen section immunohistochemistry, but what is needed is a working relationship with a pathology laboratory and dermatopathologist if the surgeon elects to send this tissue for permanent section pathology.

CONCLUSIONS

While used in only select cases, immunohistochemical staining has become an important part of the dermatologic surgeon's armamentarium. A thorough understanding of the varieties of available stains and their potential application is critical when contemplating treating rarer tumors with MMS. By combining meticulous thin frozen sections with an array of immunostains, the recurrence rate of difficult tumors may be significantly decreased, leading to clinically significant implications for the patient.

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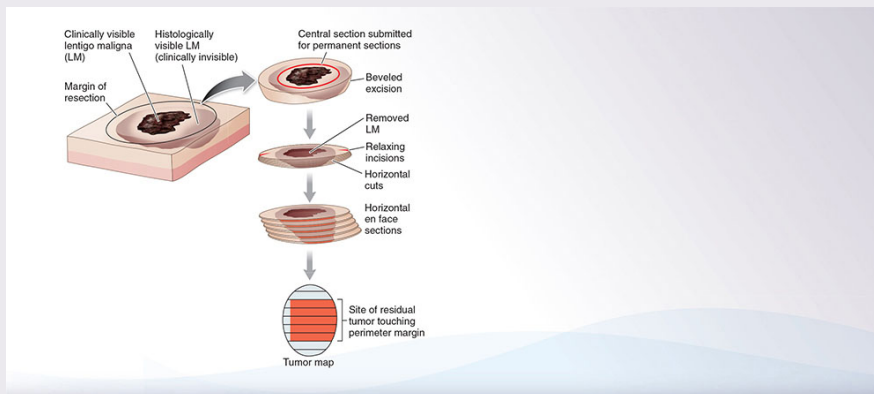
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CHAPTER 31 Mohs and Staged Geometric Excision for Lentigo Maligna

Glen M. Bowen



SUMMARY

- Lentigo maligna and lentigo maligna melanoma are very common in the elderly population.
- Surgical approaches include Mohs surgery (relying heavily on immunohistochemical staining) and staged excisions.

- Radiation therapy is particularly popular outside of the United States, while imiquimod may be better used as a neoadjuvant approach rather than monotherapy except in select patients.
- The large margins often needed mean that surgery may have significant associated morbidity.

Beginner Tips



- Closing the excisional biopsy with a single or double purse string shrinks the size of the defect down to its smallest possible surface area.
- After taking a stage for LM, a fascial plication suture and/or an intradermal traction suture can be left in place while the tissue is being processed. This allows the skin to relax along the RSTLs and facilitates the ease of closure when negative histologic margins have been confirmed.

Expert Tips



- The nuclear stains MiTF and SOX10 are less sensitive than MART-1/Melan-A, but are more specific as they do not stain dendritic processes or keratinocytes, and enable a much more accurate melanocyte density count.

Don't Forget!



- The application of topical imiquimod 5% in the neoadjuvant setting for 5 days weekly for 2 to 3 months allows for the removal of over 90% of LM lesions with a conservative 2-mm margin compared to the average requirement of a 7.1-mm margin for cases of LM untreated with topical imiquimod.
- The negative control allows for subtraction of the atypical junctional melanocytic hyperplasia common to chronically sun-exposed skin from the LM surgical margins and increased accuracy of concordance rates between dermatopathologists assessing surgical margins of LM specimens.

Pitfalls and Cautions



- SOX10 commonly stains eccrine cells and regenerating Schwann cells in scar tissue, so care must be taken to not falsely record dermal invasion in those cases.

Patient Education Points



- RT provides a gentler approach with better cosmetic outcomes, but may have a somewhat higher local recurrence rate and morbidity.
- The low mortality risk of treated LM and its prevalence in the elderly population means that therapy should always be tailored to the individual patient and an extensive discussion regarding risks, benefits, and alternatives should always be undertaken.

Billing Pearls



- Coding for true Mohs for LM utilizes the 17311-2 series and 17313-4 series used for tumors of the head/neck/hands/feet/genitalia and all other areas, respectively.
- Billing for immunohistochemical stains is in addition to standard Mohs layer billing, and is generally billed on a per-specimen basis with code 88342 for the first antibody followed by 88341 for each additional antibody. If multiple separately identifiable antibodies are applied to the slide, use one unit of 88344.

CHAPTER 31 Mohs and Staged Geometric Excision for Lentigo Maligna

INTRODUCTION

Melanoma is divided into several categories based on clinical and histologic features, including superficial spreading, nodular, lentigo maligna melanoma (LMM), and acral lentiginous melanoma. Ocular melanoma is a distinct entity with its own unique clinical and genetic features.

Lentigo maligna (LM), which is an in situ tumor,¹ and LMM, an invasive progression from LM, share some features with other melanoma subtypes, but also display unique characteristics that influence both diagnostic criteria and treatment planning. Compared with the other melanoma subtypes, LM/LMM also has the highest rates of local recurrences,^{2,3} and has a strong predilection for sites of chronic sun exposure, most commonly on the head and neck,^{1,4-7} and tends to occur in a relatively older patient population, with a peak incidence in the seventh to eighth decades.^{8,9} By contrast, superficial spreading and nodular melanomas occur at an earlier age and are distributed less commonly in sites of chronic sun exposure. Acral lentiginous/mucosal melanomas are subdivided into three subcategories, including those occurring on the palms and soles, as part of the nail apparatus, and in mucosal sites.¹⁰⁻¹³

LM is associated with unique diagnostic and treatment challenges as a consequence of its location in cosmetically sensitive areas of the head and

neck. With regards to diagnostic challenges, Caucasian skin often shows melanocytic hyperplasia (often with varying degrees of cellular atypia) at the dermoepidermal junction in chronically sun-exposed sites, and LM arises in this background.^{14–16} Distinguishing between the histologic border of where LM stops and background atypical junctional melanocytic hyperplasia begins in a background of sun-damaged skin can be challenging, since sharp lines of demarcation often do not exist,^{17,18} and there is no currently available genetic marker to distinguish between a malignant melanocyte and a nonmalignant melanocyte. Therefore, relatively large surgical margins are needed to confidently verify negative histologic margins.¹⁹ With regards to treatment challenges, the morbidity of the surgical treatment of LM needs to be balanced by the associated risk of an LM progressing to LMM, while nonsurgical treatment approaches must be carefully weighed against surgical options in terms of efficacy.

A wide range of estimates have been published regarding the natural history of an untreated LM, that is, the percent of LM that will progress to LMM, with some as low as 5%²⁰ and some as high as 50%.²¹ Risk assessment is further complicated by the relatively common occurrence of occult invasive melanoma with LM. Two separate manuscripts examining staged excision for LM coincidentally observed unsuspected invasion in 16% of excised LM specimens.^{19,22} A number of other studies have been published on the rate of upgrading LM to LMM when definitive surgery is performed, with rates ranging from 5% to 29%,^{17,19,22–28} and an average incidence of invasion calculated to be about 19% based on published studies to date.¹⁴

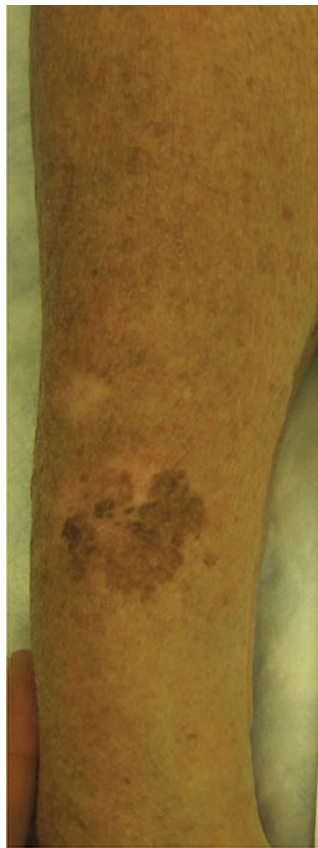
Because LMM behaves as aggressively as other subtypes of melanoma when adjusted for Breslow depth,²⁹ it is critically important that the physician properly stages the melanoma prior to definitive treatment.

When choosing a treatment approach to the patient with LM, the risk–benefit ratio must be taken into account. Factoring heavily in that calculation is the patient’s age, performance status, and cosmetic expectations.

CLINICAL PRESENTATION

It is difficult to pinpoint the exact incidence of LM in the United States since it is often not captured as a distinct diagnosis in tumor registries. An estimate has been made of 13.7 per 100,000 person-years but this is most certainly an underestimate.³⁰ The rates of LM are predicted to increase in most developed countries as life expectancy increases over time.³⁰⁻³² LM occurs most commonly in Caucasians with a predilection for chronically sun-exposed areas in a relatively older population.

The distinction between a benign lentigo (solar or simple lentigo) and LM on clinical grounds is generally a function of the LM being much larger and often with nonuniform coloring, with areas of varying pigment intensity on the brown aspect of the color spectrum (Fig. 31-1). As such, LM will generally demonstrate the “ugly duckling” sign.³³ One might imagine a Gaussian bell curve of pigmented lesions on a given patient that cluster toward a mean of shared features, with LM being a standard deviation apart in its gestalt appearance.



A



B

Figure 31-1. A. LM on the right forearm. B. Close-up view. Note the disparate color tones when compared to the surrounding lentiginos.

BIOPSY TECHNIQUES

The diagnosis of LM cannot be made reliably on clinical grounds alone. Since LM tends to be larger in terms of surface area compared to other subtypes of melanoma, sampling error may be a problem when incisional biopsies represent only a fraction of a much larger tumor.³⁴ Multiple punch or shave biopsies may be performed to sample the areas of greatest suspicion—those with the greatest color variations compared to the overall color tone of the lesion.³⁴ These areas chosen for *incisional biopsy* may be areas where the pigment is the darkest and also sometimes lighter or erythematous areas if regression is suspected, which may appear bluish gray or hypopigmented. As an alternative to multiple incisional biopsies, a long thin fusiform biopsy can be easily performed in most cases and closed with a running absorbable suture with minimal cosmetic penalty (Fig. 31-2). For very large tumors, two fusiform biopsies can be performed at 90-degree angles yielding a cruciate pattern that helps to reduce the risk of sampling error (Fig. 31-3).

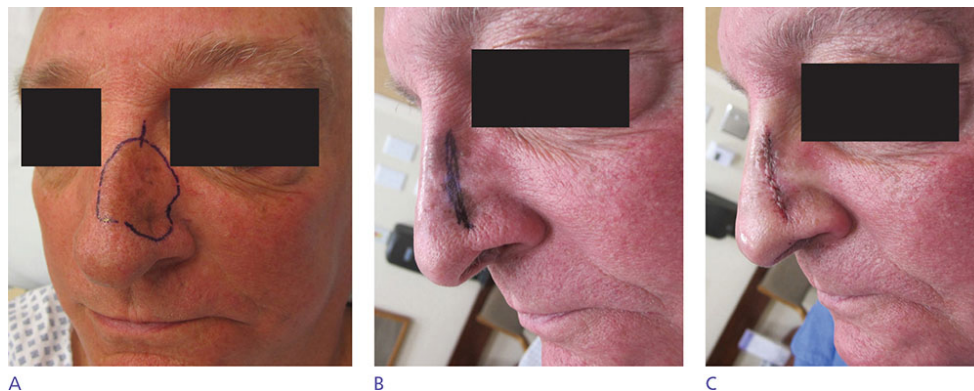


Figure 31-2. Fusiform biopsy for LM in an attempt to rule out invasion. In this case, no invasion was seen and the patient was subsequently treated with radiotherapy.

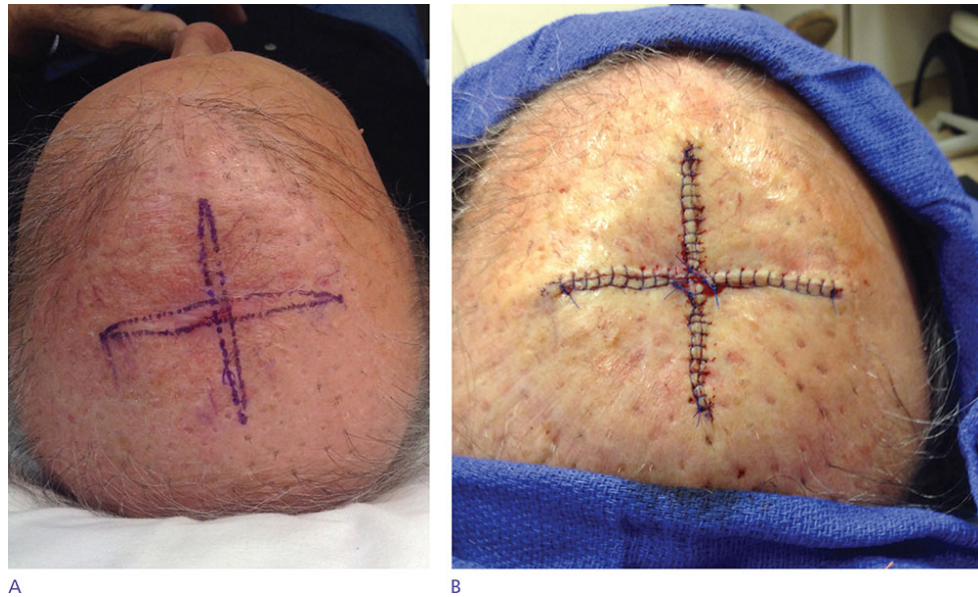


Figure 31-3. Two long, thin fusiform biopsies performed on the site of a large basal cell carcinoma treated with oral vismodegib. The biopsies were performed to screen for any areas of residual tumor. The technique may also be applied to cases of clinically large LM where there is suspicion for invasion.

The best evidence for determining whether a presumed LM specimen harbors an invasive component is by histologic review of the entire specimen, that is, an *excisional biopsy* where all visible tumor is removed.

Most patients referred for surgical treatment of LM were diagnosed by incisional biopsy, and abundant residual clinical tumor remains on physical examination. In these cases, an excisional biopsy may uncover an invasive melanoma in 19% of cases, even when the clinical suspicion for invasion is low.¹⁴ Excisional biopsies can often be closed with an intradermal purse-string suture in either a single or double configuration depending on the size and shape of the lesion (Fig. 31-4).³⁵⁻³⁸ Once the purse string has had time to heal, the definitive surgery can take place around the contracted margins of the excisional biopsy scar and reduce overall surgical morbidity.

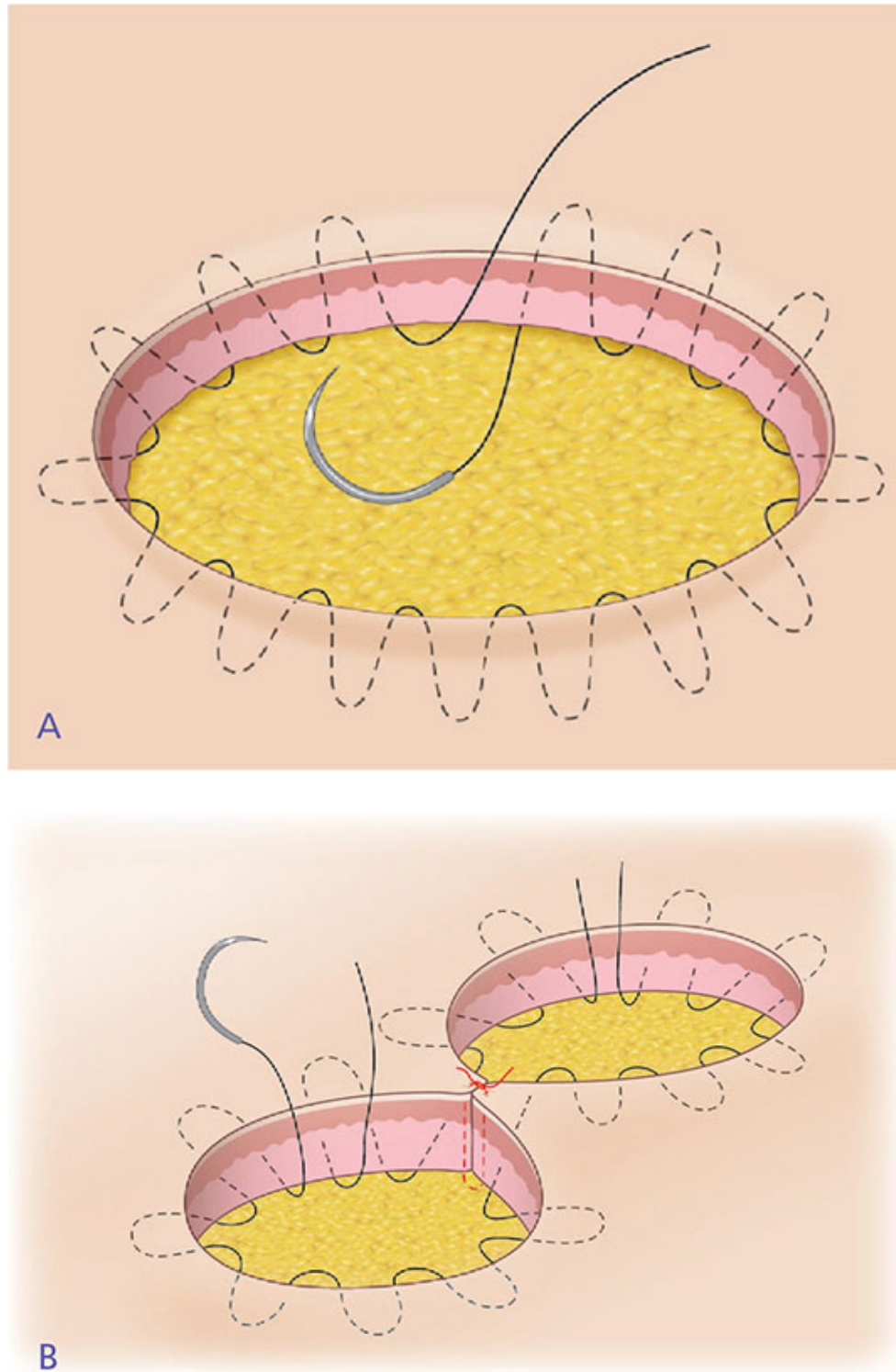


Figure 31-4. Single and double purse-string sutures. **A.** Single purse-string suture: An absorbable intradermal suture is placed 360 degrees around the defect and drawn closed. **B.** Double purse-string suture: An intradermal suture halves the defect by being placed in the center. The two smaller circles are closed with individual purse strings.

HISTOLOGY

The essential histologic feature of LM is an increase in junctional melanocytes with varying degrees of cellular atypia superimposed on a background of the stigmata of chronic sun exposure such as solar elastosis and epidermal atrophy. Many histologic features associated with LM have been described as focal findings in chronically sun-damaged skin uninvolved by LM.³⁹ It is unclear when junctional melanocytic hyperplasia on sun-damaged skin is distinguished from an LM precursor or LM, and this leads to a high rate of diagnostic disagreement among dermatopathologists.²⁹ Some dermatopathologists will evaluate junctional melanocyte atypia with grades that range from mild, moderate, to severe, the latter beginning to fuse with the entity of LM. Other terminology used to convey the concept of an LM precursor includes “evolving melanoma in situ” and “atypical junctional melanocytic hyperplasia,” though these terms are neither well defined nor uniformly utilized by dermatopathologists.

Given the lack of a specific tumor antigen that can be identified on a malignant melanocyte, the question must be asked as to how the histologic diagnosis of LM can be most accurately and reproducibly made. The histologic criteria for MIS have been described by Higgins et al. as follows: (1) poor circumscription; (2) asymmetry; (3) a predominance of individual melanocytes over nests with (a) confluent growth along the dermoepidermal junction, (b) effacement of rete ridges, and (c) pagetoid scatter; (4) nests of atypical melanocytes with (a) confluence, (b) variability in shape and size, (c) consumption of epidermis; (5) haphazard distribution; and (6) involvement of adnexal epithelium.¹⁴ The authors point out that MIS can be subdivided into LM, superficial spreading, acral lentiginous, and mucosal subtypes and within those, LM typically demonstrates effacement of the rete ridges and single cells predominating over nests of cells with varying degrees of pagetoid scatter.¹⁴

Unfortunately, many of the histologic criteria for LM can be seen in melanocytic hyperplasia in sun-damaged skin in negative control specimens (samples of skin far removed from the LM surgical site but in areas of comparable photodamage). Approximately 30% of negative control specimens have been reported to demonstrate histologic features common to LM.³⁹ In a study by A. R. Bowen et al., the only histologic feature that was

statistically significant in making a distinction between LM and the negative control was the relative disparities in melanocyte density (LM with 82.9 $\pm$ 23 cells per 400 $\times$ field vs. 32 $\pm$ 9 cells per 400 $\times$ field in the negative control).³⁹ A study of patients with LM treated with topical imiquimod showed a higher density of melanocytes in biopsies of the LM lesions that recurred compared to LM lesions that did not recur, (57.17 melanocytes per millimeters of epidermis vs. 34.12 melanocytes per millimeters of epidermis, respectively).⁴⁰ An additional study from Scotland compared LM cases that recurred following surgery to those that did not and also found that melanocyte density was strongly predictive of recurrence risk ($p = 0.0001$), with recurrence risk divided into three categories: low risk: 0 to 20 melanocytes/400 $\times$, intermediate risk: 21 to 30 melanocytes/400 $\times$, and high risk: >31 melanocytes/400 $\times$.⁴¹ The melanocyte cell count in LM is much more reproducible between pathologists than are assessments of degrees of other histologic markers such as pagetoid spread, extent of adnexal extension, and melanocyte atypia.

The degree of uncertainty in the baseline diagnosis of LM is mirrored in the downstream assessment of surgical margins when LM is excised. Thus determining the boundary between the surgical margin of LM and surrounding melanocytic hyperplasia common to chronically sun-exposed skin in Caucasians is challenging.^{2,15–18} Concerning the diagnosis of LM, two separate studies have demonstrated very clearly that concordance rates between expert dermatopathologists in diagnosing all types of melanoma is moderate at the best.^{42,43} With regards to the surgical margins of staged excisions specifically for the LM variant of melanoma, Florell et al. distributed paraffin-embedded permanent section of en face excisional margins of LM to five dermatopathologists who were asked if the margins were “positive” and required further surgery or “negative” and did not; again, concordance rates were only moderate.²⁹ Equally disturbing were the unimpressive intraobserver concordance rates when the dermatopathologist examined the same slide on two different occasions.²⁹ In this same study, despite the complexity of establishing consistency in the diagnosis of surgical margins of LM, the submission of a negative control improved concordance rates between dermatopathologists with statistical significance.²⁹

Reports on the melanocyte densities for LM/LMM¹⁴ range from 37.8 to 112 melanocytes at 400 $\times$ magnification^{39,41,44–47} compared to a range of 3.99

to 34.9 in negative controls.^{16,17,39,44,45,47–49} Problematically, the low range for LM/LMM (37.8 cells/400x) is very close to the high range for a negative control (34.9 cells/400x). For this reason, establishing a negative control for each specific patient maximizes the accuracy of comparative melanocyte density counts but does not eliminate the ambiguity. Being able to make a comparison of melanocyte density between surgical margins of LM and chronically sun-exposed skin at baseline is critically important in increasing the accuracy of the interpretation of the surgical margins of LM.¹⁷

GENETICS

There are a variety of genetic aberrations that are observed in melanoma and tend to cluster by site of occurrence. These general groupings include areas of chronic sun exposure (LM/LMM), sites of intermittent exposure such as the torso and proximal extremities (superficial spreading and nodular subtypes), and those that occur on relatively sun-protected areas including the acral and mucosal melanoma variants. LM/LMM is distributed in a similar way to the nonmelanoma skin cancers, particularly basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). LM/LMM has an extraordinarily high number of somatic mutations, in the range of 100,000.⁵⁰ In contrast to melanomas in areas of intermittent sun exposure, LM/LMM has less frequent BRAF mutations, and when present, have BRAF V600K variants more frequently than the BRAF V600E mutations more common in superficial spreading and nodular melanoma subtypes.^{51–53} LM/LMM also has inactivating mutations in NF1 (30%),⁵² increased copy number of CCND1 (20%),^{54,55} and activating mutations in KIT (10%).⁵⁶ The pattern of chromosomal abnormalities seen in comparative genomic hybridization studies comparing LM/LMM to other melanoma subtypes is also different.⁵⁴ LM occurs in a field of genetic aberrations as a consequence of both ultraviolet light directly on DNA as well as secondary effects of DNA damage due to singlet oxygen formation. This “field” where many various mutations occur over a lifetime may explain why LM occurs in a relatively older population than other melanoma subtypes⁵⁷ as well as having a higher local recurrence rate and a wider surgical margin requirement to confirm negative histologic margins. The “field-cell” phenomenon has been

demonstrated in acral and mucosal melanomas where in situ hybridization on cells surrounding the tumor in clinically normal-appearing skin has revealed histologically banal melanocytes but are found to harbor gene amplifications identical to the melanoma cells.^{58,59} It is not known if such a field effect exists in LM/LMM, though Bastian and colleagues believe are likely given the range of genetic abnormalities in sites of chronic sun exposure, the lentiginous pattern of growth that LM/LMM subtypes of melanoma share with acral and mucosal melanomas, and the tendency for local persistence.⁵⁹

TREATMENT

Therapeutic approaches to LM vary widely from institution to institution and from country to country.

SURGERY

While surgical treatment is generally considered the most effective treatment for LM/LMM, there is only limited long-term follow-up data on any LM/LMM treatment. Moreover, surgery is often associated with morbidity given the large surgical margins required to confirm complete removal of the LM,⁶⁰ especially as given the larger clinical surface area of LM, a proportionately larger margin of resection is required to confirm negative margins.⁶¹

The observed average time for a local recurrence in LM has been reported at 5.9 years.⁶² To date, there are two sequential studies from one private practice group that have follow-up data regarding staged excisions for LM/LMM longer than 5 years, with recurrence rates of 7.3% (95-month mean follow-up)⁶³ and 5.9% (138-month mean follow-up).⁶⁴ Because all other studies reporting recurrence rates have follow-up times less than 5.9 years, it is not valid to draw conclusions about the reported data on recurrence rates which range from 0% to 10%.^{19,23,26,27,61,63,65–77} There is a strong bias in the United States toward the surgical treatment of LM rather than nonsurgical techniques. Specific requirements for surgical margins for LM/LMM have not been rigorously defined.⁷⁸ It is abundantly clear from the published literature that the standard recommendations of a 5-mm surgical

margin for melanoma in situ from a consensus conference sponsored by the National Institutes of Health published in 1992⁷⁹ is frequently inadequate for the LM variant of MIS.^{19,22,75,80,81} LM is characterized by histologic borders that often extend far beyond what the clinically visible tumor margins appear to be under Wood's lamp examination.⁸² On average, 7.1 mm are required to achieve negative histologic margins for LM, and 10.3 mm for LMM.¹⁹ It has been recommended to take 9 mm^{80,83} or even >10-mm margins⁸⁴ when a wide local excision (WLE) is being performed in lieu of a staged excision for LM, with recommendations to confirm negative histologic margins prior to repair. The 9-mm recommendation is for *any form* of MIS although some dispute this and believe that there is a distinction in margin requirements for MIS in intermittently sun-exposed sites (SSMIS) or MIS in chronically sun-exposed sites (LM).^{60,78,85}

The National Comprehensive Cancer Network is a consortium of academic cancer centers across the United States and makes an annual report on treatment algorithms for melanoma and other cancers. The recommended treatment for LM is surgery with a surgical margin of 0.5 to 1.0 cm with a footnote comment that reads: "For large melanoma in situ (MIS) lentigo maligna type, surgical margins >0.5 cm may be necessary to achieve histologically negative margins; techniques for more exhaustive histologic assessment of margins should be considered. For selected patients with positive margins after optimal surgery, consider topical imiquimod (for patients with MIS) or radiotherapy (RT) (category 2B)."⁸⁶ Category 2B connotes a majority opinion among member institutions but without a unanimous consensus.

Over the years, there have been a dizzying number of published papers advocating a wide variety of surgical and histologic processing techniques. In a review of MIS of all subtypes, Higgins et al. chose to categorize surgical techniques into three categories: WLEs, staged excisions (as defined by the use of paraffin-embedded permanent sections), and Mohs micrographic surgery (MMS), defined as using frozen sections (often augmented by immunohistochemical staining).¹⁴

WIDE LOCAL EXCISIONS

The main issue with WLE for LM/LMM is selecting a margin that balances the probability that the LM will actually be removed against the morbidity of removing more tissue than is necessary in cosmetically sensitive sites. Only 42% of LM will be clear with a 5-mm margin using WLE.²² Second, an average of 7.1 mm is required to achieve negative histologic margins for LM (and 10.3 mm for LMM).¹⁹ Therefore, a 9- to 10-mm margin for WLE should be considered, which yields an excisional diameter of 2 cm not including the actual size of the original tumor.^{80,84} For this reason, WLE is associated with the greatest surgical morbidity compared to staged surgical techniques that more precisely restrain the surgical margins to the actual two-dimensional shape of the tumor footprint.

STAGED EXCISIONS

Staged excisions can be performed in a number of ways and may be defined by the manner in which the LM is removed and how it is sectioned and processed for histologic evaluation. The categories that utilize en face vertical sections are “bread-loaf” sectioning, “picture-frame” sectioning, “contour” sectioning, and “radial” sectioning. The technique that uses en face horizontal sectioning is MMS.

VERTICAL SECTIONING TECHNIQUES

Bread-loaf sectioning

The technique using vertical sections cut from parallel strips of tissue along the length of the resected specimen is referred to as “bread-loaf” sectioning. The purported advantage of bread-loaf sectioning is to allow the pathologist a view of the transition of the tumor from the inside central margin as it radiates out toward the outer edge of the tumor. Thus the yolk of a fried egg represents the residual melanoma and the surrounding egg white the tumor-free zone (Fig. 31-5). The limitation of bread-loaf sectioning is that a relatively small percentage of the three-dimensional tumor is actually visualized microscopically.⁸⁷ A study by Kimyadi-Asadi et al. reviewed cases of MIS excised with frozen sections bread-loafed at sections in 1-,

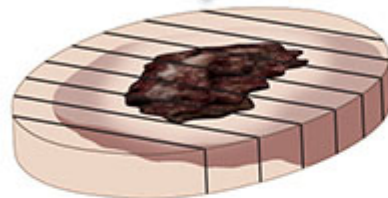
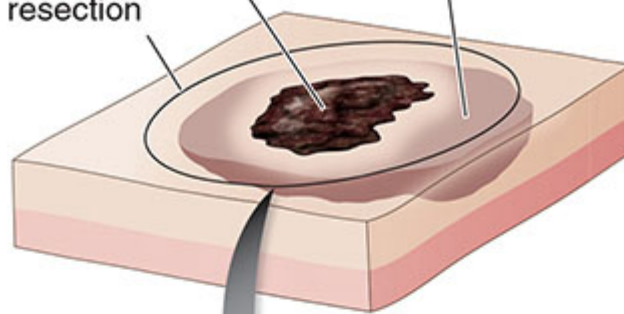
2-,4-, and 10-mm intervals and found that there was a positive margin rate of 58%, 37%, 19%, and 7%, respectively.⁸⁸ The authors concluded that bread-loaf sections would have to be cut as thin as 0.1-mm intervals in order to view close to 100% of the surgical margins.⁸⁸

The "Bread Loaf" technique

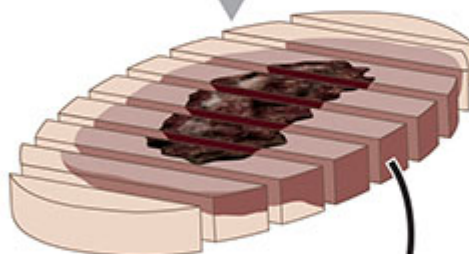
Clinically visible
lentigo maligna
(LM)

Histologically
visible LM
(clinically visible)

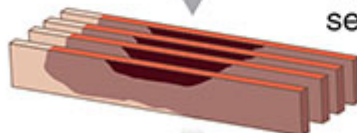
Margin of
resection



Bread-loaf
sectioning



en face vertical
sectioning



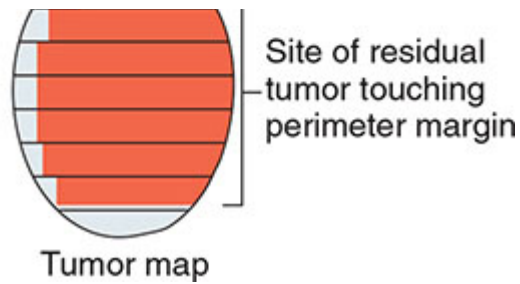


Figure 31-5. The “bread-loaf” technique.

EN FACE VERTICAL SECTIONING TECHNIQUES

“Picture-frame” sectioning

“En face” implies that the specimen is sectioned with its “face” at its peripheral margin. Johnson et al.⁶⁶ described a technique of removing a strip of tissue in the shape of a square or rectangle around the visible LM much like the frame around a picture (Fig. 31-6). The four sides of removed tissue are submitted for permanent sections cut en face with vertical sections from the outer edge toward the center of the specimen (as opposed to the horizontal sectioning used in MMS) with routine staining with H&E. The patient is brought back on subsequent visits for additional stages as needed and then ultimately for the reconstruction once negative margins had been confirmed. It is possible to process the specimens as frozen sections but Johnson and colleagues prefer formalin-fixed paraffin-embedded sections, which is the preference of many dermatopathologists.

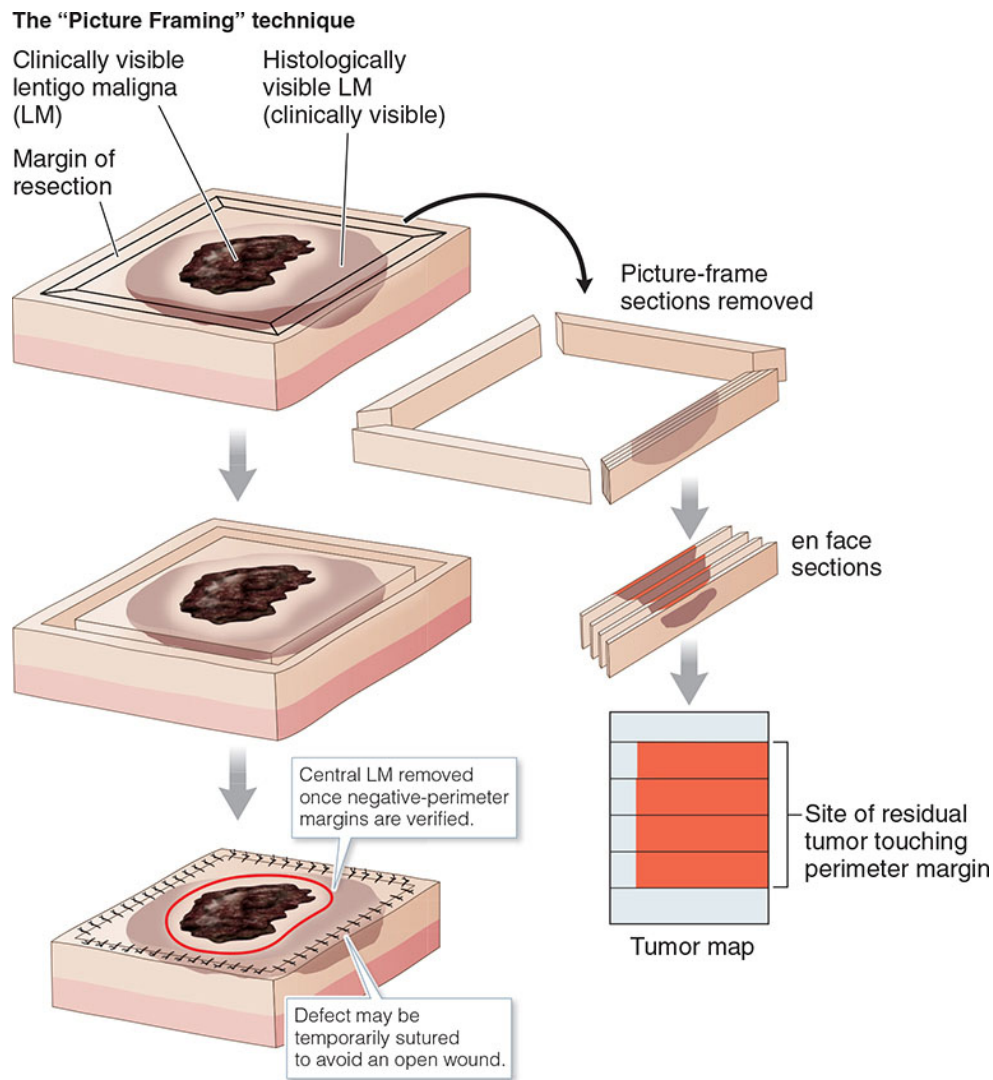


Figure 31-6. The "picture-framing" technique.

The immediate advantage of an en face vertical sectioning technique over bread-loaf sectioning is the closer approximation to a 100% evaluation of the 360-degree excised surgical margin. A study comparing bread-loaf sectioning (156 patients with a median follow-up of 81 months) versus en face vertical sectioning (136 patients with a median follow-up of 44 months) reported a recurrence rate of 6.4% versus 0.7%, respectively.⁸⁹ A second study compared bread-loaf sectioning versus en face sectioning in the surgical excisions of acral lentiginous melanoma. This study included 241 patients with a median follow-up of 41 months and compared survival rates which were 81% in the en face vertical section group versus 63% in the

transverse section group.⁹⁰ The authors refer to en face vertical sectioning as “3-D” and noted a reduction of excision margins by two-thirds, lower local recurrence rates, and longer survival times when compared to bread-loaf section analysis of tumor margins.⁹⁰

The limitations of the “square” or “picture-framing” technique are: (1) The patient must return to clinic on subsequent days for either reconstruction or another stage of surgery, which becomes increasingly onerous if multiple surgical stages are required. (2) The central portion of the tumor is not submitted until negative-perimeter margins have been evaluated. This leads to the possibility that the patient would undergo reconstruction before it was known if invasion was present in potentially 19% of cases.¹⁴ This could be problematic for T1b tumors or higher (>1.0 cm, or mitotic figures >1/mm, or ulceration) where a sentinel lymph node biopsy could be considered. Additionally, the excision margins for invasive melanoma call for their depth to include the adipose layer to fascia.⁸⁶ Some surgeons argue against the utility of a sentinel lymph node biopsy in melanoma.^{91–93} However, there are two approved adjuvant agents available for patients with positive lymph nodes (interferon-alpha2b approved in 1995⁹⁴ and ipilimumab approved in 2015),^{95,96} as well as several clinical trials available to patients with positive sentinel nodes. Without interrogation of the sentinel lymph nodes, these patients are ineligible for adjuvant clinical therapies they may have otherwise be anxious to try. (3) The potential for miscommunication between the dermatopathologist and the surgeon regarding the specific locations of residual tumor. This potential source of error is minimized with frozen sections where the surgeon also serves as the pathologist.

Contour sectioning

A similar method was reported, called the “spaghetti technique,” which converted the square or rectangular shape to a more organic shape which more closely follows the contour of the visible LM.⁷⁷ The resultant strips of removed tissue are not necessarily straight lines as with the picture-framing method but can be laid flat and cut en face with vertical sections. This approach involves circumscribing the visible tumor with the desired margin and sectioning a 360-degree narrow band of tissue, leaving the LM in the center and then temporarily suturing the defect closed (Fig. 31-7). As with

the picture-framing technique, the residual LM is subsequently removed from the center once negative-perimeter margins have been defined. The purpose of leaving the residual LM in the center is to avoid an open wound while waiting for the results from formalin-fixed paraffin-embedded sections. With either the picture-frame or contour techniques, the surgeon has the option of suturing the 360-degree perimeter defect closed to avoid an open wound while the patient awaits the pathology report.

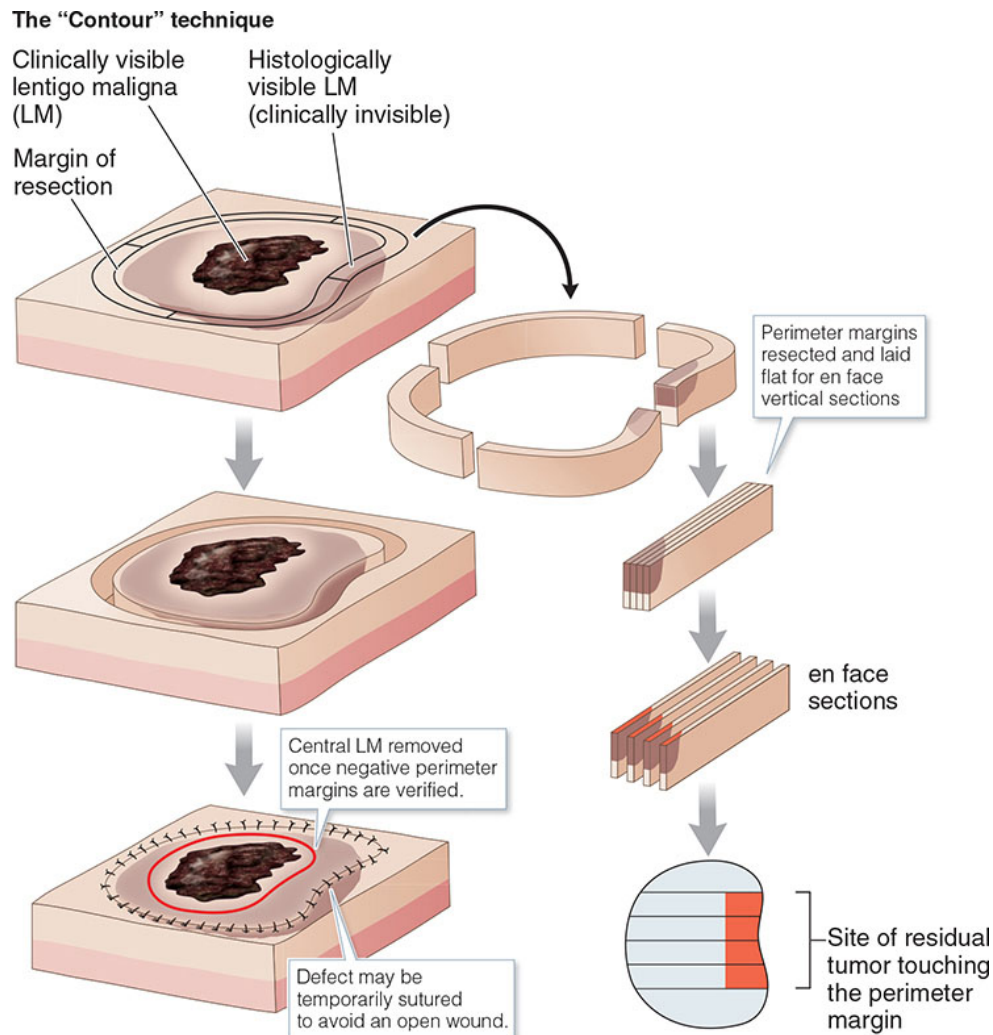


Figure 31-7. The "contour" technique.

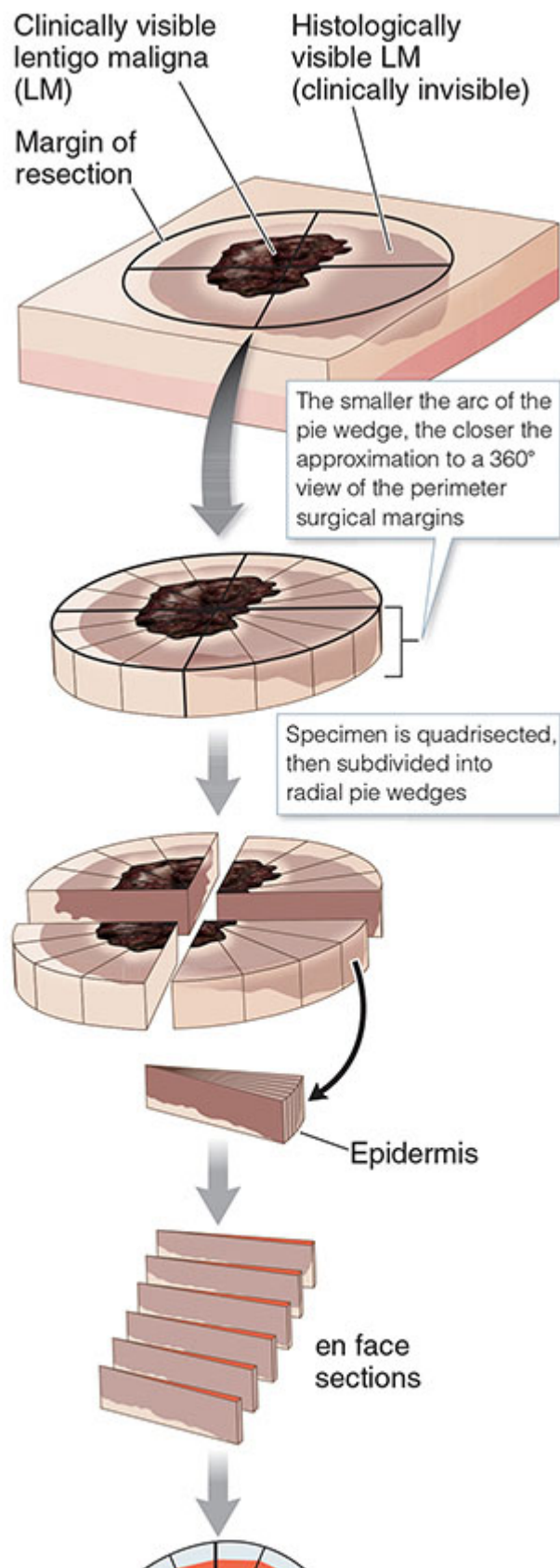
The advantage of this technique over the picture-frame technique is that the excised specimen more closely follows the contour of the original tumor and removes less tissue. It shares the disadvantage that the central portion of the LM is not removed until after negative-perimeter margins have been

confirmed. This introduces the risk that invasion, if present, is not detected until after the reconstruction has been performed. Also, some advocates of picture framing may argue that by submitting polygons with distinct shapes, there is less risk for miscommunication between the dermatopathologist and the surgeon as to the exact location(s) of residual tumor. The accuracy of that communication is going to be a function of the quality of the tumor mapping by the surgeon submitting the specimens and the dermatopathologist transmitting correct sites of tumor involvement to that map.

Radial sectioning

An alternative histologic view of LM is preferred by some pathologists and Mohs surgeons and involves “radial” sectioning. In this technique, the specimen is removed and is grossed in by sectioning the tumor into radial sections similar to slices of pie wedges.²⁶ Each individual pie wedge is cut en face with vertical sections generating either frozen or formalin-fixed paraffin-embedded sections (Fig. 31-8). This technique has the advantage of allowing a view of the central portion of the LM, where (1) invasion can be ruled in or out, and (2) one can assess the diminution of the melanocyte density from the center to the outside edge of the excision, and in this sense, provides an internal “positive control” from the center of the residual tumor. The ability to see the decline in melanocyte density from the center of the LM to the outer surgical margin is the touted advantage of bread-loaf sections.

The "Radial Section" technique



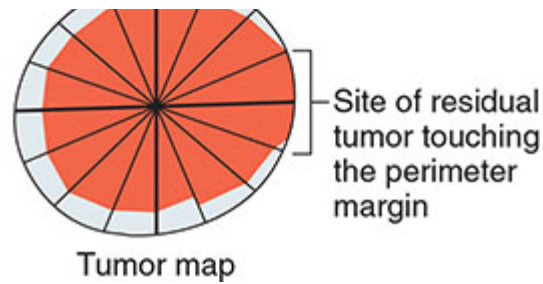


Figure 31-8. The “radial section” technique.

Critics of radial sectioning point out that the width of the outside arch of each pie-wedge section prohibits viewing of a true 360-degree perimeter of the tumor margins as opposed to the view rendered with MMS, picture framing, or contouring (Fig. 31-8). Proponents of the radial technique argue that the approximation of the area under a curve is accurate if the integrals are sufficiently narrow to approximate the 360-degree perimeter margin, and that published recurrence rates are similar to those described with staged en face techniques or MMS.^{19,26} Another criticism of the radial technique is the time requirement for the grossing-in process usually involving defatting, quadrisectioning the tumor, inking the quadrants, and subdividing each quadrant into thin pie-wedge sections (Figs. 31-9 and 10). Proponents argue that the additional grossing-in time is marginal and can be delegated to a qualified histotechnologist, and that the added benefit of being able to visualize the diminution of the melanocyte density from the center to the perimeter is well worth the extra labor and time of grossing-in the specimen. When using frozen sections with immunostaining to augment H&E, this technique may be performed in a single day.

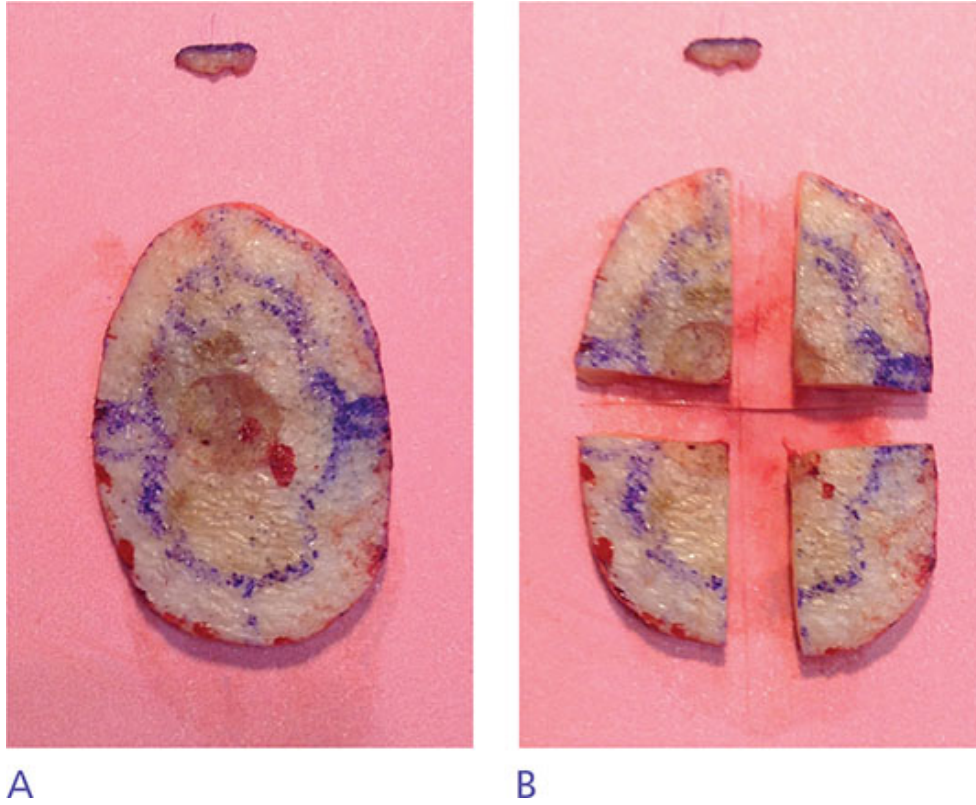


Figure 31-9. Grossing-in a radial section LM with a negative control. **A.** Excised LM from the right helical rim with a negative control. **B.** Specimen is quadrisectioned.

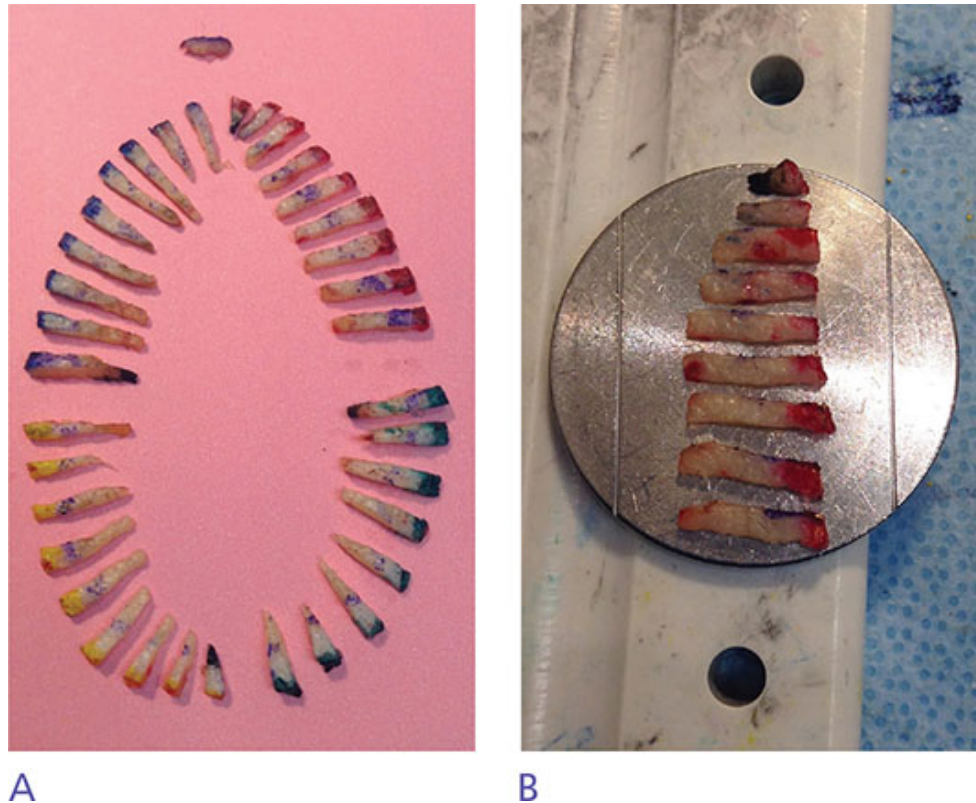


Figure 31-10. Mounting radial pie wedges on the cutting chucks. **A.** Each quadrant sectioned into six thin pie-wedge sections (number of pie wedges varies with the size of the tumor). **B.** Pie wedges from each quadrant mounted on chucks for en face sectioning in cryostat.

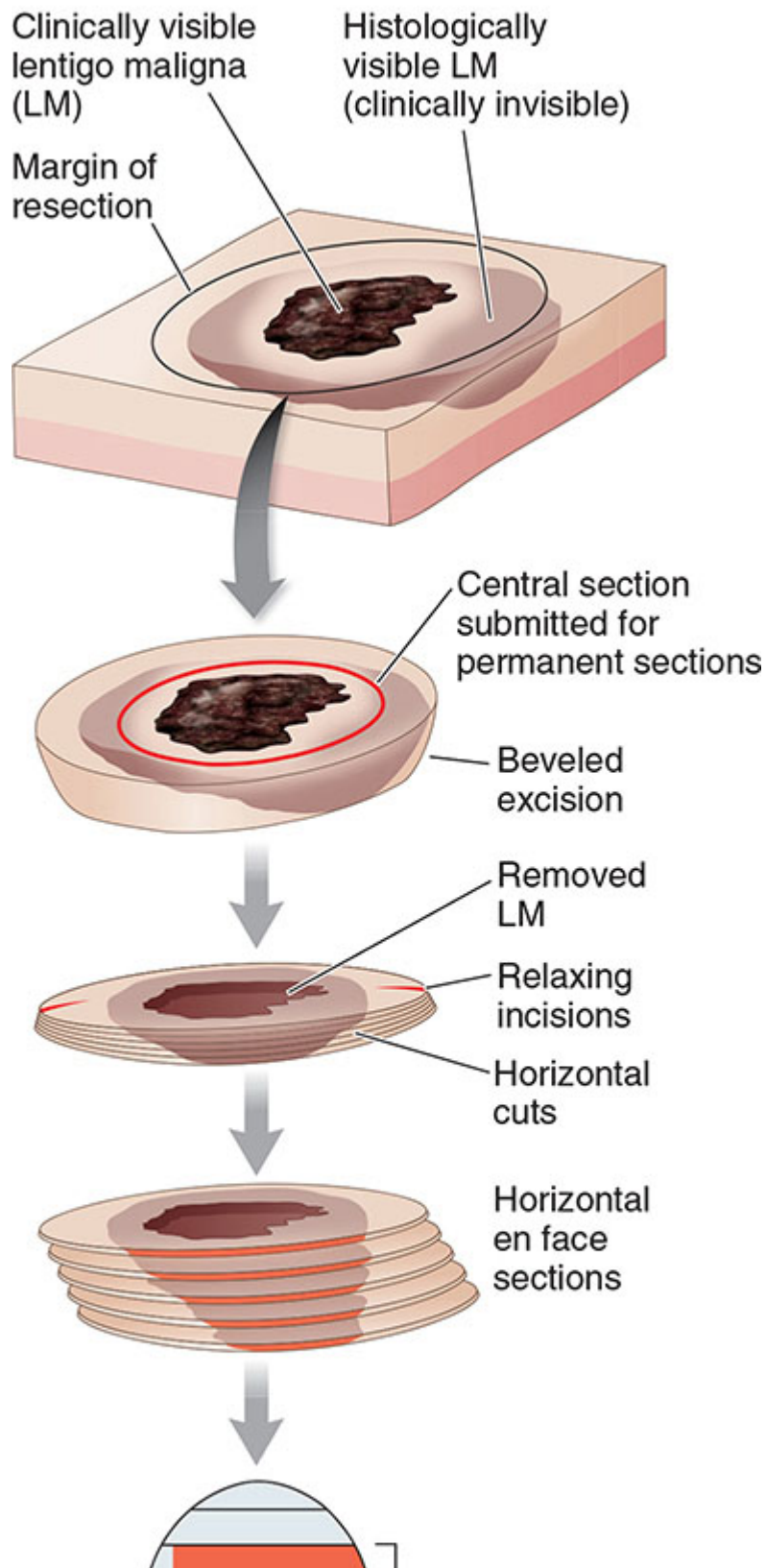
EN FACE HORIZONTAL SECTIONING TECHNIQUE

Mohs micrographic surgery

MMS involves cutting frozen tissue with en face horizontal sections. Most commonly, the central portion of the tumor containing visible signs of LM is removed as a debulking layer which is submitted in formalin for paraffin-embedded permanent sections⁹⁷ as is the case with en face vertical sectioning techniques (picture-framing and contour techniques). The removed perimeter tissue is generally sectioned in a cryostat at a thickness of 4 μ m and stained with H&E and is often augmented with immunostains. If margins are judged to be positive, additional layers are taken until negative histologic margins can be confirmed (Fig. 31-11).⁹⁷ There are numerous published

studies on MMS for LM/LMM that demonstrate its effectiveness at tissue sparing,^{27,70,72,98–100} though follow-up times are not sufficient to adequately evaluate recurrence rates.

**The Mohs micrographic surgery
“Horizontal sectioning” technique**



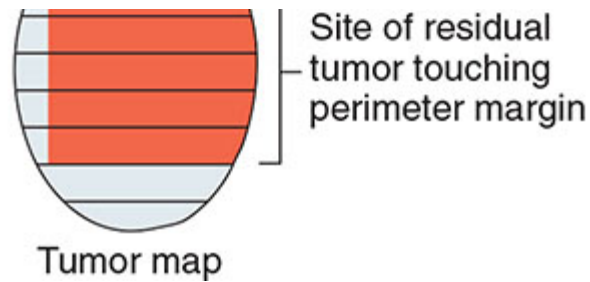


Figure 31-11. The Mohs micrographic surgery “horizontal sectioning” technique.

The advantages of MMS with en face horizontal sectioning on frozen tissue is that the surgery can usually be completed in 1 day and that grossing is fairly rapid. The disadvantage, as with the picture-framing and contouring techniques, is that the central LM specimen is submitted for permanent sections (and the reconstruction is performed) before the LM has been properly staged.⁸⁷ This approach has the potential to put the surgeon in an awkward position of having to explain to a patient that they have an upstaged tumor that has already been reconstructed in an average of 19%¹⁴ of cases with inadequate depth of excision to the fascia recommended for invasive melanoma.⁸⁶ Critics of this approach argue that definitive surgery is being performed prior to accurate staging of the cancer.

Another very important disadvantage to MMS and radial sections utilizing frozen tissue is the compromised ability to accurately assess cellular atypia with frozen sections.¹⁰¹ In this case, the pathologist reviewing frozen sections is reliant on pattern recognition and melanocyte density counts where it is extremely difficult to distinguish bordering melanocytic atypia in chronically sun-damaged skin.^{39,41}

Tissue processing: paraffin-embedded permanent sections versus frozen sections

Paraffin-embedded permanent sections are preferred by dermatopathologists for interpreting LM margins since the resolution allows for more accurate assessments of melanocyte/cellular atypia. The downside to permanent sections is the processing time. Because cells are comprised mostly of water and because water expands when frozen, frozen sections for LM/LMM are hampered by several artifactual perturbations. There is a tendency for

melanocytes to bloat when frozen, making them much more difficult to distinguish from surrounding basal cells/keratinocytes with H&E staining, and an assessment of individual cellular atypia is nearly impossible.^{14,44,102} This blurring of the distinctions between melanocytes and keratinocytes greatly hampers the ability of the dermatopathologist to assess cellular atypia as well as melanocyte number and distribution. In a paper entitled, “Are en face frozen sections accurate for diagnosing margin status in melanocytic lesions?” 15 dermatopathologists examined margin status of both melanoma and nonmelanoma surgical excisions by comparing en face frozen sections with paraffin-embedded permanent sections and found a discrepancy regarding margin status in 40% of cases; the authors concluded that en face frozen sections are not suitable for evaluating margin status in melanomas.¹⁰¹ Additionally, frozen sections are cut thicker than are paraffin-embedded sections which leads to crowding that can simulate the pattern of confluence seen in MIS.^{87,101–103}

Stonecipher et al. also advocated rush permanent sections over frozen sections when applying MMS to LM/LMM to improve the accuracy of interpreting melanocytic cellular atypia.¹⁰⁴ Others have argued that there is good correlation between frozen section MMS for LM/LMM with H&E staining alone compared to permanent sections,^{98,100} though Zitelli et al. who reported 90% specificity and 100% sensitivity comparing frozen sections to permanent sections using H&E staining alone have subsequently advocated immunohistochemical staining on frozen sections for LM/LMM to improve accuracy.^{44,102} Because concordance rates between dermatopathologists in interpreting staged excisions of LM with paraffin-embedded permanent sections is only moderate at best,²⁹ great caution should be used by Mohs surgeons relying on frozen sections to assess LM margins.

Slow Mohs (staged excisions with rush permanent sections)

Slow Mohs is a technique to address the shortcomings of frozen section analysis of surgical margins for LM/LM and involves rush permanent section analysis of surgical margins. This is the technique used in the descriptions of the picture frame⁶⁶ and contour techniques⁷⁷ utilizing en face vertical

sections and by some advocates of the radial technique.^{19,26} The term “Slow Mohs” is a misnomer for two reasons: (1) The Mohs surgeon is generally not the person interpreting the slides, as they are usually read by a dermatopathologist. (2) Many times the specimens are not submitted for en face horizontal sections as is done in MMS but rather with perimeter en face vertical sections (picture framing, contour, or radial techniques). In this regard, techniques that employ formalin-fixed paraffin-embedded sections are more accurately referred to as “staged excisions with rush permanent sections.” Proponents of this technique advocate greater accuracy in margin assessment, as opposed to MMS with frozen sections.⁸⁷

Frozen sections augmented with intraoperative immunohistochemical stains

Given the inherent difficulties associated with freeze artifact, there have been numerous publications on the addition of intraoperative immunohistochemistry (IHC) to frozen sections for LM/LMM as a means to circumvent the problem of decreased cellular detail and clarity when compared to permanent sections. Because cellular detail is mostly obscured with frozen sections, immunostaining may help to discriminate between the melanocytes and basal cells/keratinocytes, though it cannot distinguish between a malignant and a benign melanocyte.¹⁰⁵ In making a judgment as to whether or not the immunostained melanocytes are benign or malignant, one must rely on melanocyte density and cluster patterns to make that determination.^{39,41} Immunostains have been applied to a number of melanocytic lesions evaluated with permanent sections where there is potential for ambiguity such as melanocytic hyperplasia in chronically sun-exposed skin, desmoplastic melanoma, and pigmented actinic keratosis, to name a few.^{17,45,48,106–108}

MART-1/Melan-A

A number of manuscripts appear in the literature touting a variety of immunostains for frozen section analysis of surgical margins for LM.^{44,47,49,102,109,110} The most commonly used antibodies are MART-1

(melanoma antigen recognized by T-cells)^{111,112} or Melan-A (which recognize epitopes on the same transmembrane glycoprotein of melanocytes as does MART-1).^{113,114} They have been demonstrated to be more sensitive for the detection of melanocytes than HMB-45.¹¹²

Many clinicians have reported the successful implementation of MART-1/Melan-A immunostaining on frozen sections in MMS for LM/LMM.^{39,102,103,109,110,115} Figure 31-12 shows Mart-1 immunostaining on a radial section for LM. Although the addition of the MART-1/Melan-A immunostain can decrease the ambiguity incident to freeze artifact, there are several additional caveats to consider. MART-1/Melan-A antibodies will bind to cells that contain melanosomes which include melanocytes, but also other cells such as keratinocytes and melanophages, as well as avidly staining the dendritic processes of the melanocytes, which makes melanocyte density calculation very difficult in many cases. There have been several reports of pigmented lesions with associated lichenoid infiltrates stained with MART-1/Melan-A that were erroneously interpreted as having positive surgical margins secondary to promiscuous immunostaining that simulated MIS.^{108,116} Such reports are worrisome, since approximately 6.7% of cases of melanoma can have associated lichenoid inflammatory patterns.⁸⁷ Additionally, pigmented actinic keratoses, common in chronically sun-exposed skin can also have avid MART-1/Melan-A staining and simulate a positive surgical margin.¹¹⁷ Fixed drug eruptions have also posed a similar diagnostic dilemma with MART-1/Melan-A staining.¹¹⁸

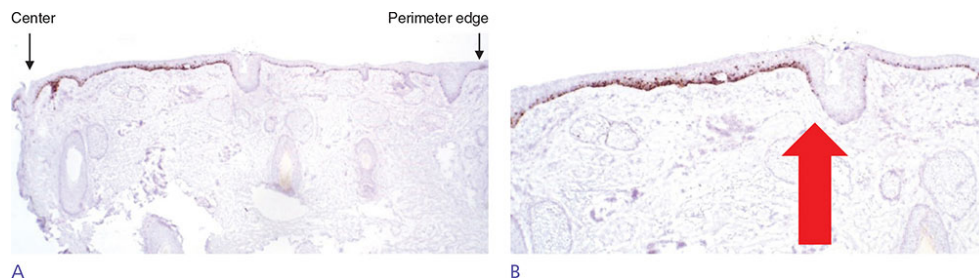


Figure 31-12. Mart-1 immunostaining of a radial section of LM. **A.** Radial sections immunostained with Mart-1 at low power showing the termination of the LM. **B.** Higher-power view of the presumed terminus of the LM as indicated by the *red arrow*.

Because melanosomes are cytoplasmic and do not enter the nucleus, immunostains that are specific for melanocytic nuclei can help to overcome

the lack of specificity inherent in melanosome-based immunostaining. Two such antibodies are MiTF and SOX10. It has recently been observed that actual melanocytic nests can be seen in lichen planus that could simulate melanoma in situ; therefore, even the increased specificity of the nuclear stains must be viewed in the context of scenarios prone to false-positive reads of melanoma in situ.¹¹⁹

NUCLEAR IMMUNOSTAINS (MITF AND SOX10)

MiTF (microphthalmia transcription factor)

The two commercially available antibodies that bind to melanocytic nuclei are MiTF (microphthalmia transcription factor),¹²⁰ a nuclear transcription factor, and SOX10, also a transcription factor expressed in melanocytic nuclei.^{121,122} Nuclear stains have greater specificity since keratinocytes, melanophages, dendritic processes, etc. do not stain with these antibodies, decreasing the risk for overinterpreting melanocyte densities at surgical margins.⁴⁹ Cellular structure has been reported to be less perturbed with nuclear stains,^{106,123} though cellular detail will still be inferior compared to paraffin-embedded permanent sections. A study comparing Melan-A to MiTF found that the melanocyte density in the surrounding tumor-free chronically sun-exposed skin was higher with the Melan-A than with the MiTF and that the latter stain gave a more “crisp” outline of melanocyte nuclei.¹²⁴ The downside of nuclear stains is that the gain in specificity is countered by a loss of sensitivity. (Fig. 31-13 compares dual MART-1 immunostaining to SOX10 on an LM.)

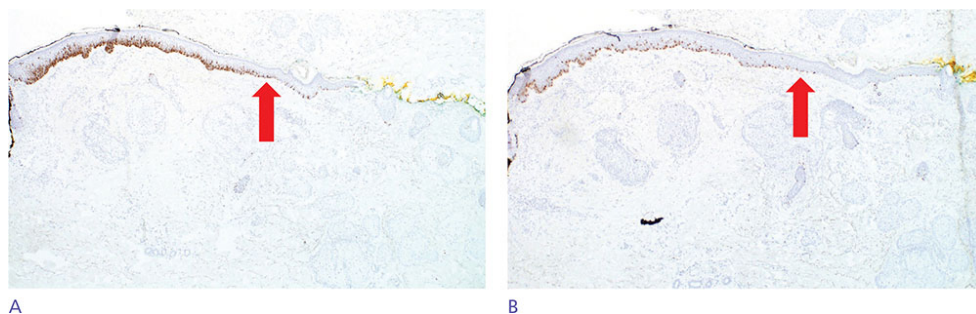


Figure 31-13. Mart-1 (A) and SOX10 (B) immunostaining at 40× on a radial section of LM. The *arrows* indicate the approximate distal terminus of the LM as it extends from the center of the radial section to the perimeter surgical margin.

Making the distinction between the surgical border of LM/LMM and the melanocytic hyperplasia common in chronically sun-exposed skin is very difficult; therefore, an accurate calculation of melanocyte density can be extremely helpful, especially when a negative control is included where a comparison of densities between the LM/LMM and surrounding skin can help clarify surgical margins.^{17,29,39,41} The advantage of a nuclear versus a cytoplasmic stain is demonstrated by increased melanocyte densities with MART-1/Melan-A stains compared to MiTF presumably due to promiscuous staining of melanosomes in keratinocytes, dendritic processes, and melanophages.⁴⁹ The nuclear stains allow for an easier and more accurate count of melanocyte densities compared to cytoplasmic stains. There are a number of reports on the comparative densities of melanocytes in LM/LMM compared to chronically sun-exposed skin. Compare the MART-1 immunostain at 400x to the SOX10 immunostain at the same magnification in [Figure 31-14](#); the nuclear stain provides more clarity when making a specific density evaluation.

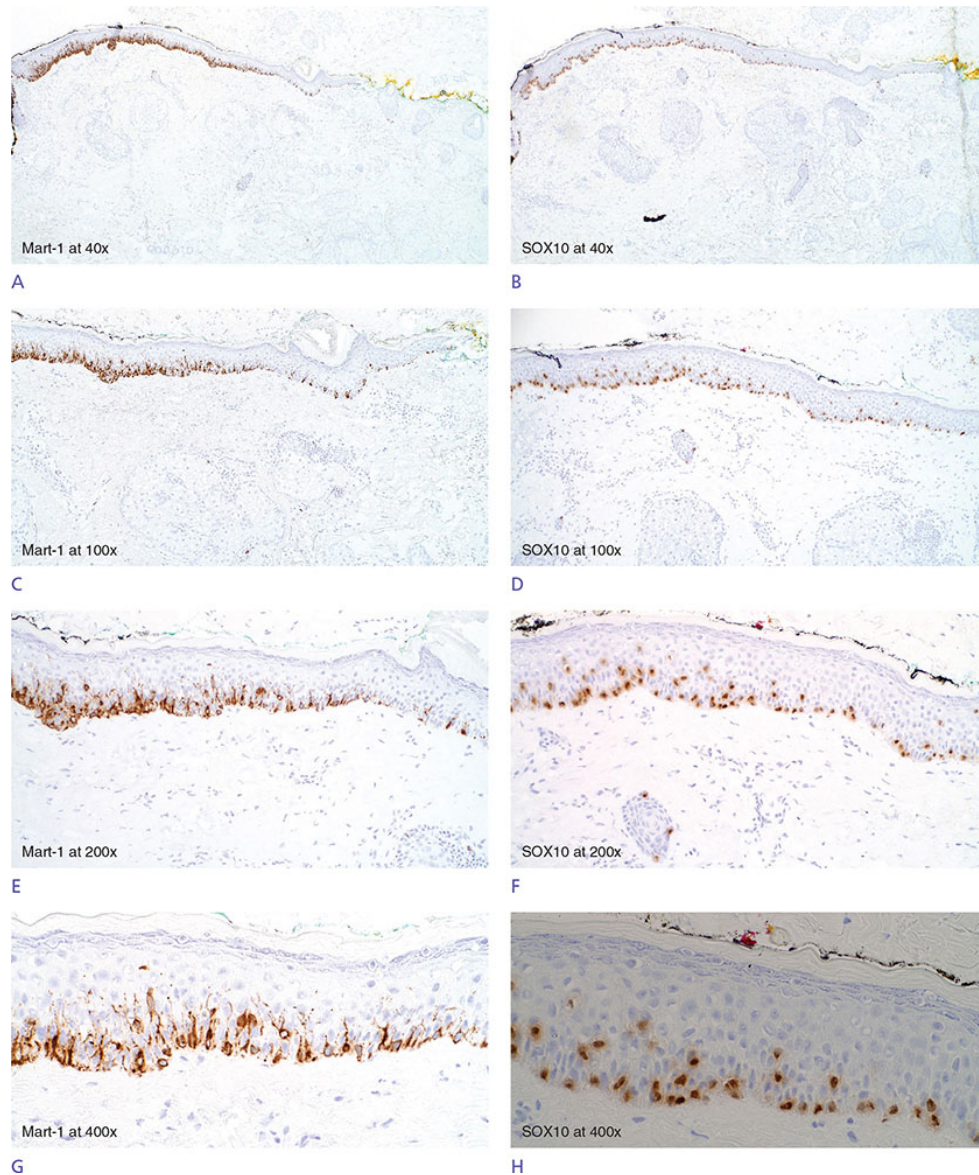


Figure 31-14. A. Mart-1 at 40×. B. SOX10 at 40×. C. Mart-1 at 100×. D. SOX10 at 100×. E. Mart-1 at 200×. F. SOX10 at 200×. G. Mart-1 at 400×. H. SOX10 at 400×.

Although MiTF adds specificity in comparison to MART-1/Melan-A, it is by no means perfectly selective, and can also bind to epitopes in dermal dendritic cells (antigen-presenting cells), some fibroblasts, Schwann cells, smooth muscle cells, and mast cells,^{105,123,125–129} and can lead to the false reporting of a nidus of invasive melanoma. For these reasons, one can never be overconfident in relying on MiTF and density counts as the single criterion in margin assessment.

SOX10

SOX10 (Syr-related HMG-box gene 10) is a neural crest transcription factor confined to the nucleus and is upstream to MiTF in that it regulates the expression of MiTF.⁸⁷ The expression of SOX10 is limited to melanocytes, eccrine glands, and Schwann cells, and unlike MiTF, is less apt to stain-associated fibroblasts and histiocytes (but more likely to stain desmoplastic melanomas compared to MiTF).¹³⁰ On the other hand, another study concluded that MiTF is slightly more sensitive than is SOX10 in tagging melanocytic nuclei.¹²² To evaluate the relative staining features of MART-1, SOX10, and H&E, [Figures 31-13 to 31-16](#) give some examples for comparison.

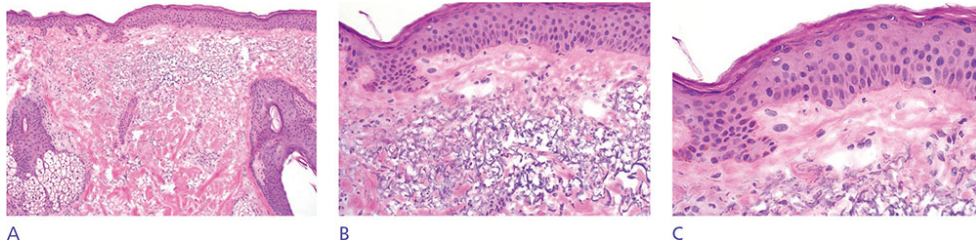


Figure 31-15. H&E staining at 100× (A), 200× (B), and 400× (C) on a radial section of an LM.

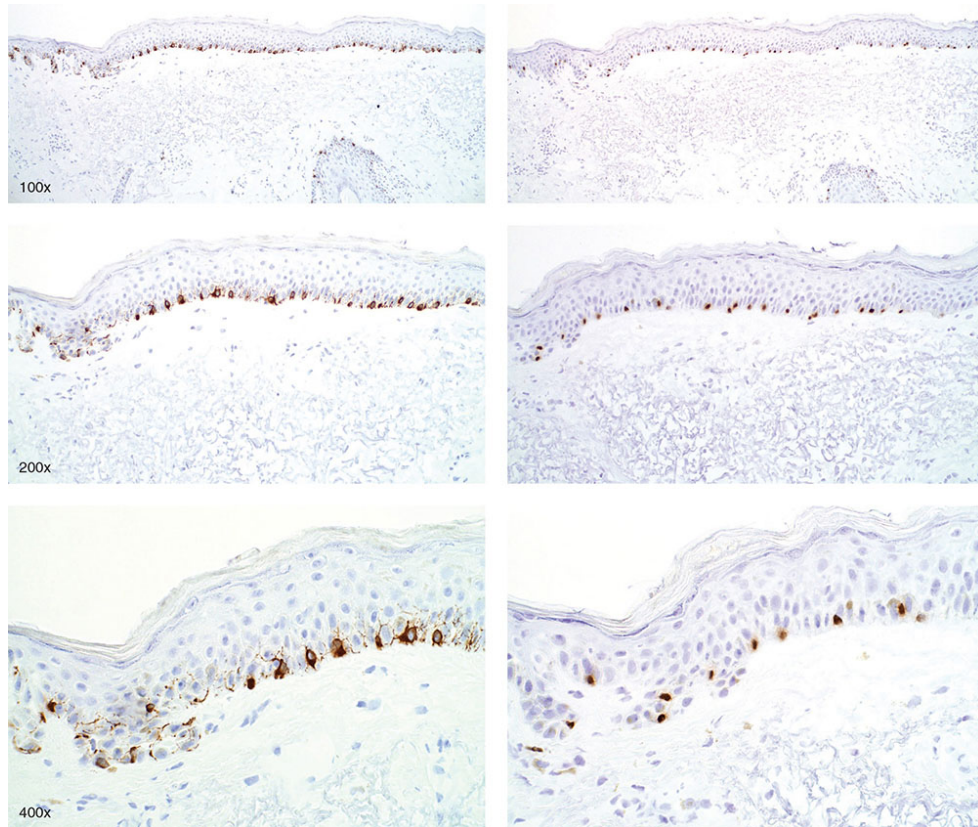


Figure 31-16. Comparison of the negative control with Mart-1 (**left**) and SOX10 (**right**).

A potential pitfall of SOX10 is found in a recent report of excisions of desmoplastic melanoma where a high percentage of excision specimens had SOX10 staining in surrounding scar tissue determined *not* to be part of the desmoplastic melanoma. It was hypothesized that regenerating schwannian cells in the scar were staining rather than the melanocytes.¹³¹ The authors cite two prior reports where SOX10 either weakly stained scar tissue (vs. the avid staining in desmoplastic melanoma)¹³⁰ or did not stain scar tissue at all.¹³² The discrepancy between these studies may be due to the use of different clones of the SOX10 antibody, differences in laboratory technique, or varying stages of maturation of the scar tissue examined.¹³¹ However, with regards to scar tissue, SOX10 has been reported to be less likely to stain fibroblasts and histiocytes than S100 or MiTF,¹³⁰ while maintaining a higher specificity.

SUMMARY

Regardless of which surgical technique is paired with which processing technique, the accuracy of surgery is reliant on the quality of the personnel involved in removing, processing, and interpreting the histology. If the process is performed with skill and attention to detail, the specific technique and process are less important than is the ultimate success in attaining the final goal: confirming negative histologic margins before the reconstruction is performed.

RADIATION THERAPY

Unlike in the United States, there is a bias toward treatment of LM with RT in Europe, Australia, and New Zealand. The advantage of RT is improved cosmesis with no surgical scarring outside of the original biopsy site as well as reduced morbidity in terms of subjecting the patient to both the excision(s) and reconstruction. Superficial RT penetrates to a depth of the dermoepidermal junction and then falls off exponentially.¹³³ Because LM tracks down the follicular appendages, it has been recommended that the RT dose be adjusted to achieve a depth of 5 mm since hair follicle depth ranges from 0.5 to 4.5 mm.¹³³

RT is hyperfractionated in the treatment of skin malignancies; a lower dose is given per fraction (RT treatment session) with a higher number of fractions delivered in total. Hyperfractionation has the advantage of less toxicity and consequentially less fibrosis. Hypofractionation is the converse, where a higher dose is given in a fewer number of treatments which is more convenient for the patient but results in greater morbidity.¹³⁴ RT can also be delivered to the skin in the form of brachytherapy with the application of a mold plate where the RT is diffusely delivered to the skin in a topical manner.¹³⁵ The determination of field size has been reportedly augmented by the use of a Wood's lamp and *in vivo* confocal microscopy in assessing tumor margins prior to treatment,^{136,137} and then adding an additional centimeter to the treatment field.¹³³

Two criticisms of RT as monotherapy for LM are that (1) it is hyperfractionated and (2) the cosmetic benefits tend to decline over time. In most RT clinics, treatment for LM requires 4 to 6 weeks of daily therapy (Monday to Friday) to achieve the intent to treat dosages of 54 Gray at 2 Gy

per fraction.¹³³ In the United States, many patients balk at this approach due to the time commitment. Although the initial cosmetic results of RT are excellent, over time the treated sites may begin to develop atrophy, hypopigmentation, telangiectasia, and decreased skin elasticity, making RT a less attractive option for the relative young patient. These consequences can be partially but not completely overcome by hyperfractionation.¹³⁸

RT must be used with great caution around free margins, particularly the eyelids. Posttreatment fibrosis can lead to ectropion formation with ensuing xerophthalmos.¹³⁹ An increasing number of dermatologists are using electronic surface brachytherapy (ESB) as an intraoffice nonsurgical treatment for nonmelanoma skin cancer, and although not approved by the Food and Drug Administration, there may be a temptation to apply ESB to LM. A recent report cites a male in his 60s with a BCC of the infraorbital cheek treated with ESB at a dose of 42 Gy in 12 fractions with a Xofig device (Xofig Inc) using a 20-mm cone.¹⁴⁰ A local recurrence of the BCC was noted within 10 months with contracture of the conjunctiva in the socket of a previously enucleated eye combined with lower lid ectropion with subsequent displacement and loss of his ocular prosthesis. There are no published data on the safety and efficacy of ESB for LM, and very little data with regards to nonmelanoma skin cancer.¹⁴¹

Despite risks at certain anatomic sites, in expert hands RT can be a very effective treatment for LM. A meta-analysis of nine studies using RT as monotherapy for LM was performed by Fogarty et al.¹³³ In this study, 349 LM lesions were treated with RT with a local recurrence rate of 5% with a median follow-up time of 3 years. Since the median time to recurrence of LM is 5.9 years,⁶² a 5% local recurrence rate at 3 years would be likely to increase with a follow-up time approaching 6 or more years. RT is a reasonable alternative to surgery, particularly in cases of very large tumors and/or elderly patients where the morbidity of surgery outweighs the inconvenience of hyperfractionated RT.

TOPICAL IMIQUIMOD 5% CREAM

Monotherapy

Imiquimod cream exploits Toll-like receptors that stimulate an inflammatory response when triggered that can treat genital warts^{142,143} and was subsequently been approved by the FDA for actinic keratosis and superficial BCC of the trunk.^{144,145} Imiquimod is an enticing option for patients with LM, as it avoids the morbidity and complications associated with surgery and RT. It has not been approved by the FDA for LM, but has been extensively used off-label as either monotherapy^{146–167} or as neoadjuvant therapy before surgery to decrease the size of the surgical margin requirement^{168,169} or as adjuvant therapy when the surgical margins for LM were close or positive.¹⁷⁰

There is a wide range of biological responses in patients treated with topical imiquimod, with some patients developing signs of vigorous inflammation while others demonstrating no inflammation whatsoever. Although an exact correlation between the degree of the inflammatory response and the complete clearance of LM has not been established, there is a trend toward higher efficacy with increasing inflammation when using imiquimod as a neoadjuvant therapy followed by complete excision.¹⁶⁹ Pooled data from 45 studies of topical imiquimod demonstrate that complete responses fall short of RT and staged surgical excisions, with complete clinical responses of 78.3% (95% CI, 73.6% to 82.9%) and complete histologic responses of 76.2% (95% CI, 71.4% to 81.0%).¹⁷¹

Neoadjuvant imiquimod followed by staged excision

The largest prospective controlled study to date using imiquimod in the neoadjuvant setting randomized 91 patients to receive either topical imiquimod alone 5 days a week for 3 months versus imiquimod in combination with tazarotene 0.1% gel added twice a week to augment drug penetration and enhance the inflammatory response.¹⁶⁹ After undergoing staged excisions, no evidence for residual tumor was seen in 78% of patients receiving the imiquimod/tazarotene combination compared to 64% of patients receiving imiquimod alone. Although the data showed a trend toward higher complete responses with greater inflammation, the difference did not meet statistical significance. Of note, 72% of patients had no residual tumor and were clear with 2-mm margins, while 28% required a second

stage of surgery with an additional 3.5-mm margin (total of 5.5-mm margins) for an average required margin of slightly less than 3 mm. This compares very favorably to the average requirement of 7.1-mm margins for LM not pretreated with topical imiquimod.¹⁹ Figure 31-17 addresses the purported advantage of neoadjuvant topical imiquimod for a hypothetical LM with a 10-mm clinical margin where the first scenario (A) calculates the surgical defect size for the average 7.1-mm requirement compared to the average 3-mm margin required for patients treated with neoadjuvant topical imiquimod prior to surgery. Figure 31-18 projects the 7.1-mm surgical margin requirement to a 3-mm margin requirement for a 10-mm LM on the Mona Lisa.

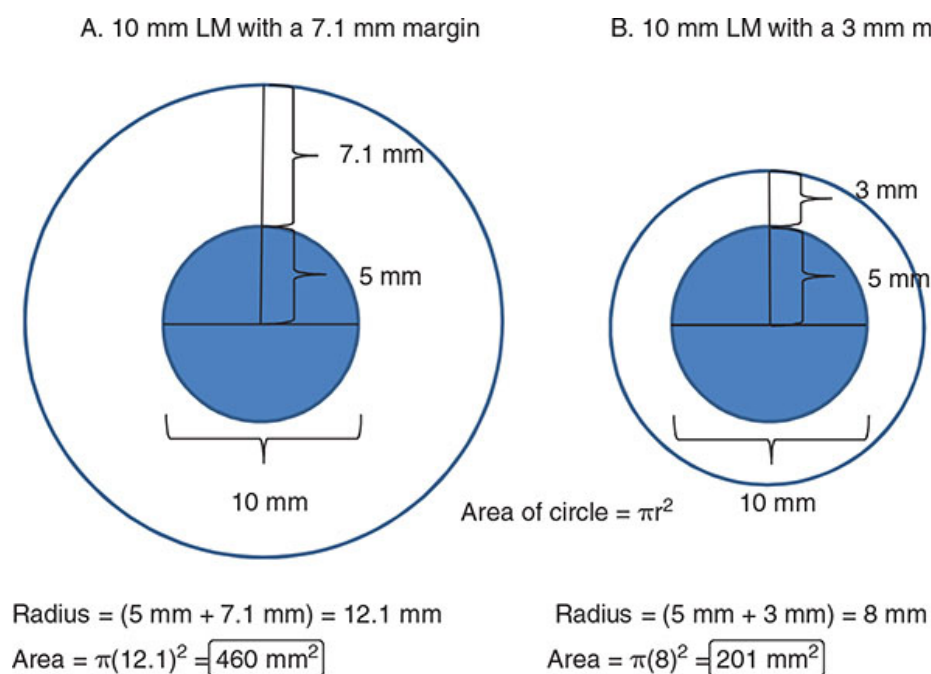


Figure 31-17. A. A 10-mm-diameter LM treated with a 7.1-mm margin. B. A 10-mm-diameter LM treated with a 3-mm margin.

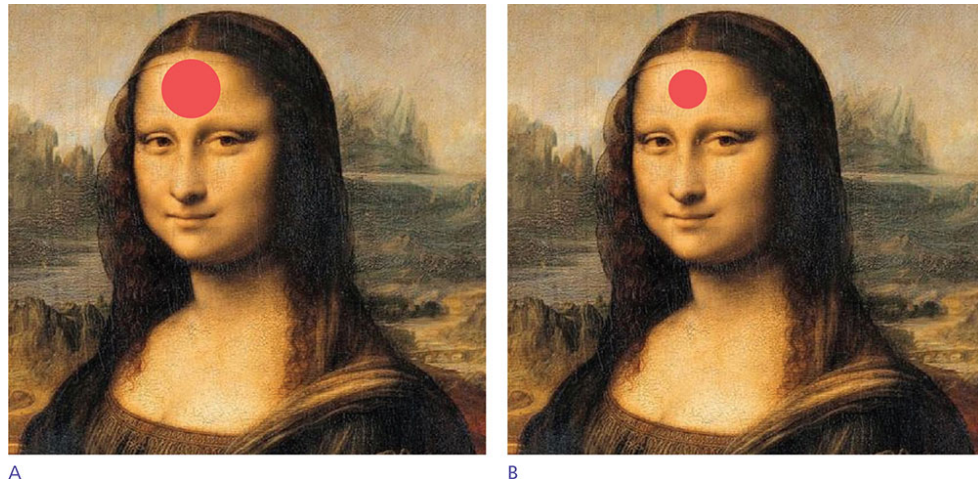


Figure 31-18. A. A 10-mm LM with a 7.1-mm margin defect scaled down on the Mona Lisa. B. A 10-mm LM with a 3-mm margin.

OTHER NONSURGICAL OPTIONS

There are other potential nonsurgical treatments for LM that have not been tested to date. One candidate is local injection of a viralytic agent.

Talimogene laherparepvec (T-VEC) is a genetically modified herpes virus where the gene segments associated with disease have been excised and a gene coding for granulocyte macrophage colony stimulating factor (GM-CSF) has been inserted. It has been approved by the Food and Drug Administration for the treatment of metastatic melanoma.¹⁷² The viralytic agent is injected into accessible melanoma tumors or nodal metastases. The viruses demonstrate a predilection for melanoma cells and, once internalized, replicate, destroy the cell, and release virions and GM-CSF which attracts inflammatory cells.¹⁷³ T-VEC-treated patients have shown abscopal responses (effects in metastatic foci away from the injection site), suggesting that a systemic immune response may be stimulated.¹⁷⁴ Theoretically, this approach may have a therapeutic effect on LM as a means to avoid surgery.

RISK–BENEFIT CALCULATION

Perhaps the greatest challenge in the treatment planning for LM is making a risk–benefit calculation as accurately as possible in helping the patient in

choosing a treatment plan. Surgical approaches are quite effective in terms of complete responses, but often result in large surgical defects with consequential complicated reconstructive surgery. RT provides a gentler approach with better cosmetic outcomes, but may have a somewhat higher local recurrence rate and morbidity. Because LM is, by definition, an in situ tumor, it has no associated mortality risk assuming the diagnosis has been made accurately. The actual risk of an LM to the patient then becomes the statistical risk of its eventual progression to an invasive melanoma with an associated risk of metastases, directly related to the depth of invasion.

One study suggested that the lifetime risk of eventual transformation of LM to LMM is 4.7% for those age 45 and 2.2% for those age 65,²⁰ while another estimates the risk as closer to 50%.²¹ It, therefore, appears that only a minority of cases of LM are destined to become invasive.

Debloom et al. reported that in local recurrences of excised melanoma in situ, 22.6% of the recurrences were invasive, with a mean Breslow depth of 0.94 mm.¹⁷⁵ Examining over 2000 cases of LM in the Huntsman Cancer Institute database, approximately 20% of recurrent LM cases were invasive, although all recurrences had a Breslow depth of less than 1.0 mm and were staged as T1a (stage IA) LMMs. The 5-year mortality rate for a T1a melanoma is approximately 5%.¹⁷⁶

Assuming 5.9% local recurrence rate, with 20% of these invasive, and with the majority being <1.0 mm in depth (T1a tumors), a 0.06% mortality risk (or 6 deaths out of every 10,000 patients) would be expected.

The low mortality risk of treated LM in elderly patients invites complexity when choosing a therapeutic intervention. For younger or healthy patients, a 20% risk of invasion is a significant concern. In such patients, a more aggressive approach with the goal of complete response is reasonable. RT should be used carefully in the relatively young, since there is a tendency for a decline in the cosmetic appearance in treated sites over time combined with the increased risk of carcinogenesis, though that number is likely measured in decades and not years. In older patients, concern regarding developing skin cancer in irradiated sites becomes less of an issue, as does the worry about the potential for declining cosmesis in an RT-treated site. In patients over 80 years of age, the average life expectancy is much lower and may be heavily influenced by other comorbidities (diabetes, chronic renal failure, congestive heart failure, etc.). In such cases, a less aggressive

approach or even observation may be a reasonable course of action. In principle, the physician should partner with the patient in defining the treatment goal: reducing the risk that the patient will eventually die from a metastatic melanoma balanced by making every effort to minimize disfigurement and morbidity.

CONCLUSION

The state-of-the-art practice in terms of both diagnosing and treating LM/LMM is far from ideal. The discovery of a molecular marker to distinguish between a malignant and benign melanocyte continues to elude research scientists. Along with the myriad genetic changes that occur in melanoma, it is not possible at the current stage to predict which patients with LM are destined to progress to invasion and potential metastatic disease, especially as the great majority will likely live out a natural life expectancy with LM untreated.

Case 1



A



B



C



D



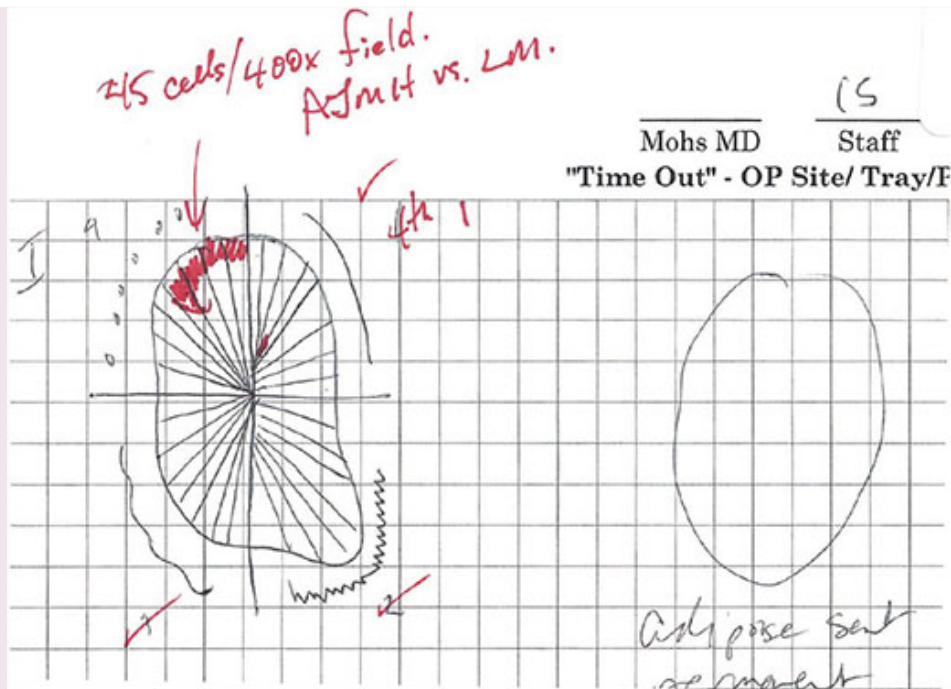
E



F



G



H

An 88-year-old female was referred for an LM of the left cheek diagnosed with an incisional biopsy. Residual pigment was evident at the time of referral with a very ambiguous clinical margin. An excisional biopsy was performed and closed with a double purse string. Invasion was detected to a depth of 0.36 mm with no other adverse features (Stage IA: T1a). A staged excision was performed and negative margins were confirmed after two stages and the defect was closed with a complex primary repair with a unilateral M-plasty. One can see the area of suspicion for residual tumor at the 10 to 12 o' clock position that, in retrospect, should have been taken on the first stage.

Case 2



A



B



C



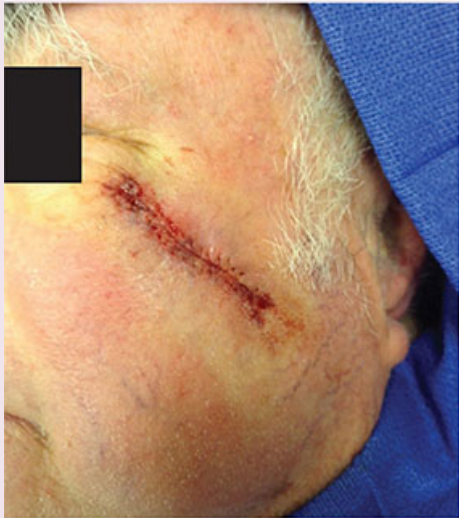
D



E



F



G

An 84-year-old male was referred for an LM of the left malar cheek diagnosed with an incisional biopsy. An excisional biopsy was performed and closed with a double purse string. No invasion was detected and the patient was treated with topical imiquimod 5% cream Monday through Friday for 2 months. A conservative staged excision with 2-mm margins was performed 2 months after cessation of topical therapy with no signs of residual tumor histologically. The defect was closed with a complex primary repair with M-plasties.

Case 3



A



B



C



D



E



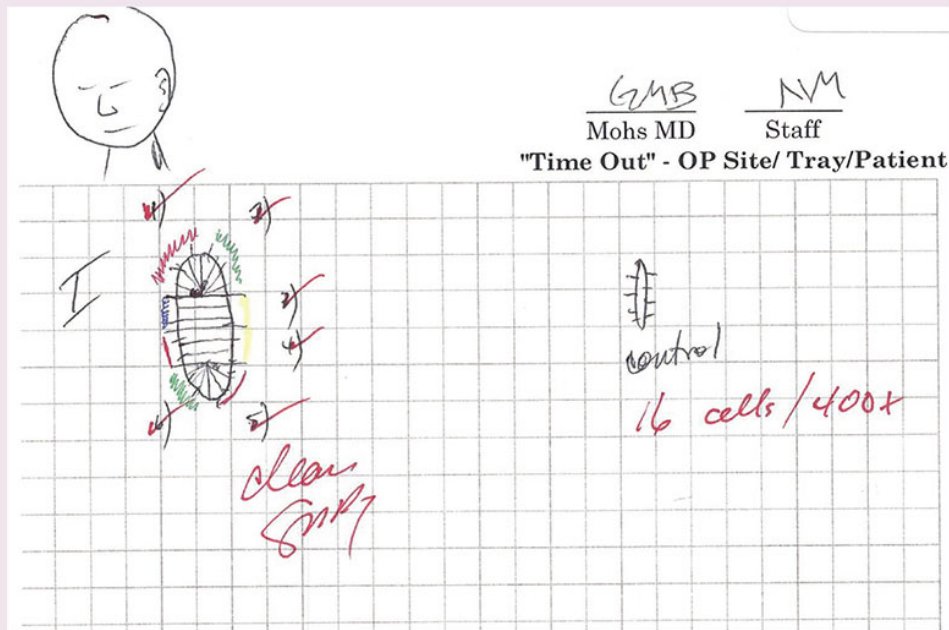
F



G



H



I

A 68-year-old female was referred for an LM of the left cheek diagnosed with an incisional biopsy. Residual tumor was seen clinically at the time of consultation, so an excisional biopsy was performed and closed with a double purse string. No invasion was detected and the patient was treated with neoadjuvant topical imiquimod 5% cream Monday through Friday for 2 months. A conservative staged excision with 2-mm margins was performed 2 months after cessation of topical therapy with a small amount of tumor centrally but negative-perimeter margins >2 mm from the outer edge. The defect was repaired with a complex primary repair.

Case 4



A



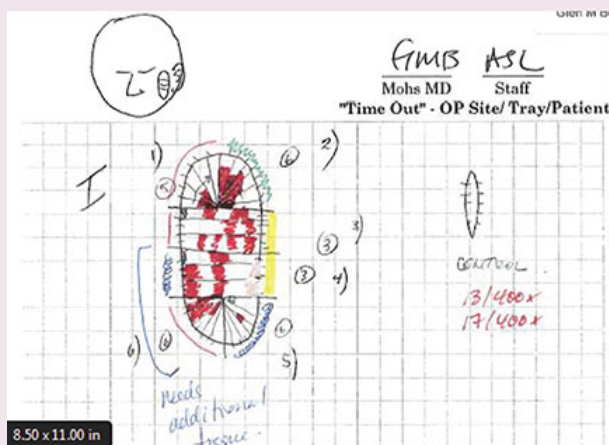
B



C



D



E



F

An 83-year-old female was referred for an LM diagnosed with an incisional biopsy. In contrast to the previously presented cases with invasion, this case was clinically very suspicious for invasion and demonstrates the inadequacy of the incisional biopsy in this case. An excisional biopsy was performed and closed with a linear closure and purse strings at the inferior and superior poles. Invasion was detected to a depth of 0.65 mm with no other adverse histologic features (Stage IA, T1a). A staged excision was performed with a 1.0-cm margin to the fascia. Residual in situ tumor was seen on the medial inferior edge (7 to 9 o' clock) and a second stage was performed and negative margins were confirmed. The defect was repaired with a complex primary repair.

Case 5



A



B



C



D



E



F

A 74-year-old male was referred for an LM diagnosed with an incisional biopsy. An excisional biopsy was performed and closed with a double purse string. No invasion was detected and he was treated with neoadjuvant topical imiquimod 5% cream Monday through Friday for 2 months. A conservative staged excision with 2-mm margins was performed 2 months after cessation of topical therapy. No residual tumor was detected and the defect was repaired with a complex primary repair.

Case 6



A



B



C



D



E

A 67-year-old male was referred for an LM from the left lateral chin diagnosed with an incisional biopsy. The clinical photograph shows some residual light brown pigment. An excisional biopsy was performed and closed with a double purse string. Invasive melanoma was seen on

histologic review to a depth of 0.48 mm with no other adverse histologic features (Stage IA, T1a). A staged excision was performed with a 1.0-cm margin to the fascia. Negative margins were confirmed on the first stage and the defect was closed with a rhombic flap with a modified Z-plasty.

Case 7



A



B



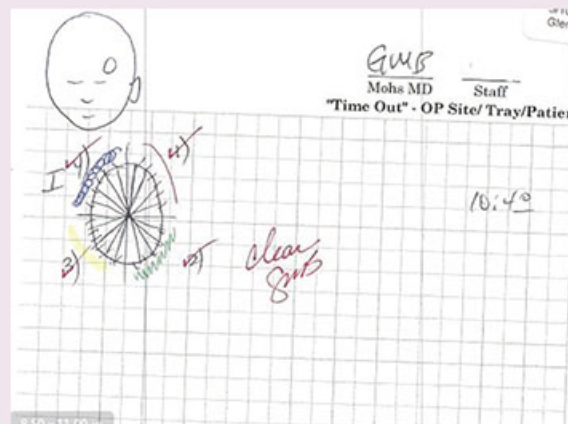
C



D



E



F

A 71-year-old male was referred for an LM of the left forehead diagnosed with an incisional biopsy. On examination, there is some faint residual brown pigment remaining. An excisional biopsy was performed and closed with a double purse string. Invasion was detected to a depth of 0.27 mm without any other adverse histologic features (Stage IA, T1a). A staged excision was performed with a 1.0-cm margin to the fascia with no signs of residual melanoma. The defect was closed primarily.

Case 8



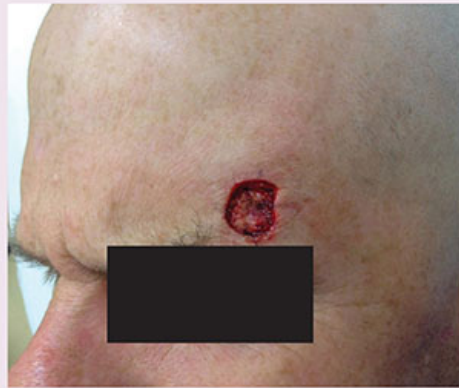
A



B



C



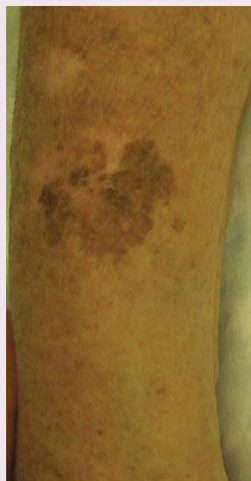
D



E

A 52-year-old male was referred for an LM of the left forehead diagnosed with an incisional biopsy. An excisional biopsy was performed and closed with a double purse string. No invasion was detected and the patient was treated with neoadjuvant topical imiquimod 5% cream Monday through Friday for 2 months. Two months after cessation of topical therapy, a conservative staged excision was performed with 2-mm margins with no evidence for residual tumor. The defect was repaired with bilateral advancement flaps.

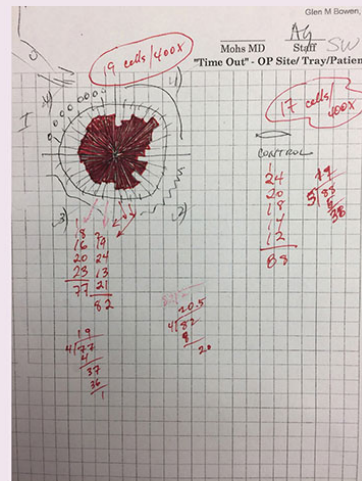
Case 9: Recurrent LM



A



B



C



D



E

A 79-year-old woman was referred for LM of the right forearm diagnosed with an incisional biopsy. A staged excision was performed with abundant central in situ tumor seen but negative-perimeter margins >2 mm were confirmed on the first stage. The defect was repaired with a bilobed transposition flap. The melanocyte density count was 19 melanocytes/400 $\times$ in the LM and 17 melanocytes/400 $\times$ in the negative control.

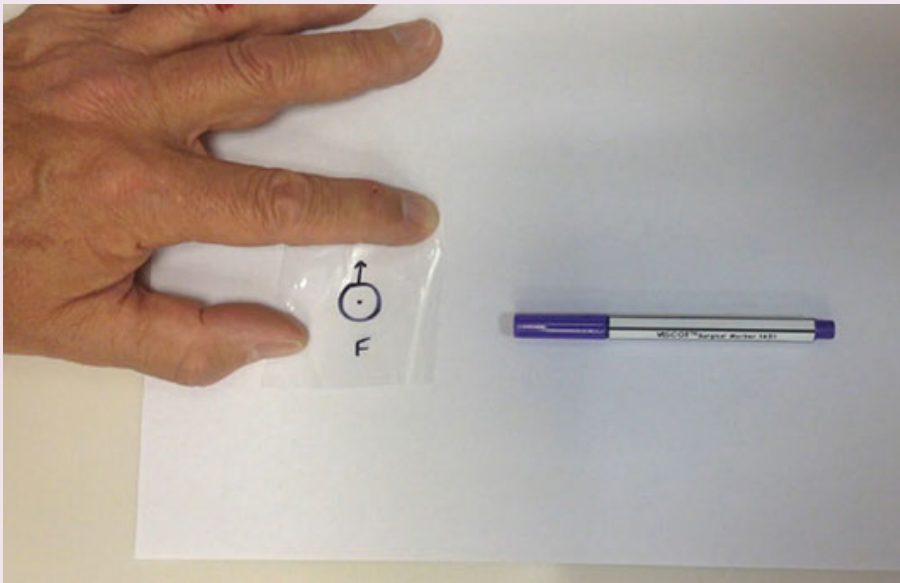


Three years later, a local recurrence was documented by the referring dermatologist and the patient was again referred for treatment. A staged excision was performed at the site of the local recurrence beginning with an 8-mm margin. There was residual melanocytosis centrally but with a widely negative-perimeter margin. The melanocyte density count of the re-excised LM was 28 melanocytes/400 $\times$ compared to 22 melanocytes/400 $\times$ in the negative control. The defect was repaired with a rhombic transposition flap.

Case 10

An 86-year-old male was referred for LM of the right zygomatic temporal region. The lesion was treated with neoadjuvant topical imiquimod 5% cream Monday through Friday for 2 months. Three months after cessation of topical therapy, he presented for a conservative staged excision with 2-mm margins.

- A. A transparent template around the LM was created at the commencement of topical imiquimod therapy. The template is reversed, a marking pen is used to trace the undersurface of the template (F means “front of the template” and the arrow indicates the 12 o’ clock position).



- B. The template is transferred onto the skin of the patient centered over an India ink tattoo placed at the time of the initial referral.



C. An approximate 2-mm margin is transcribed 360 degrees around the tumor outline.



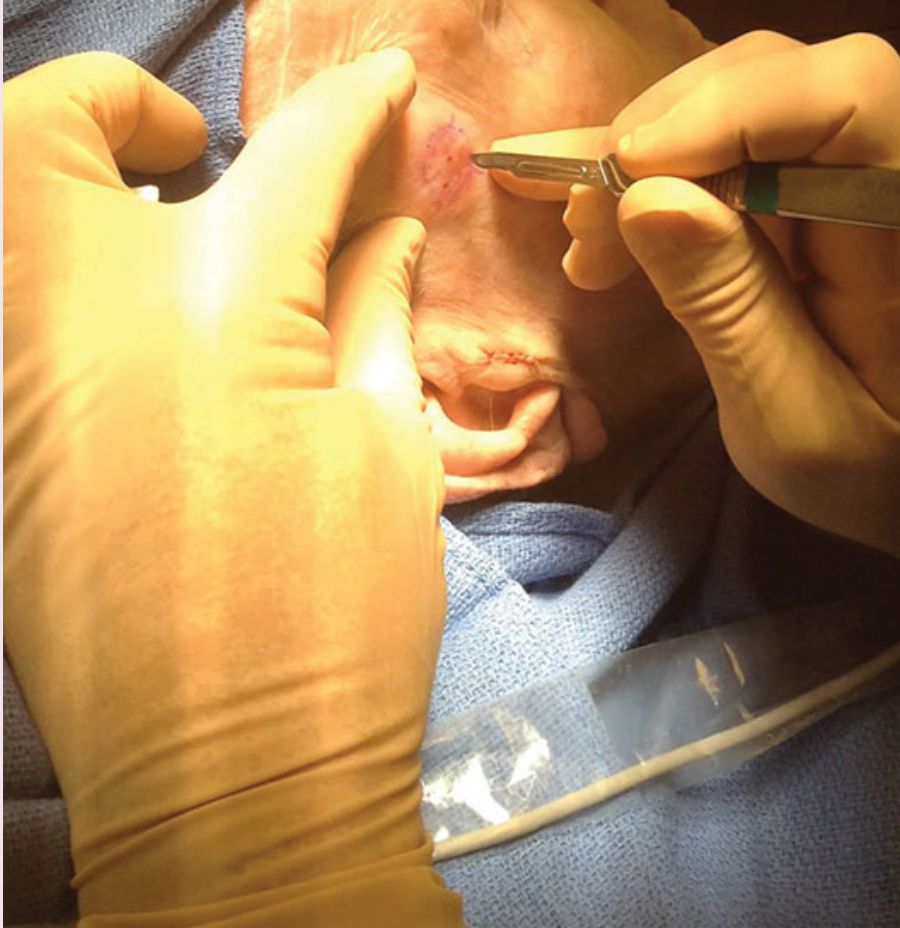
D. A thin fusiform negative control is sampled from the right preauricular cheek.



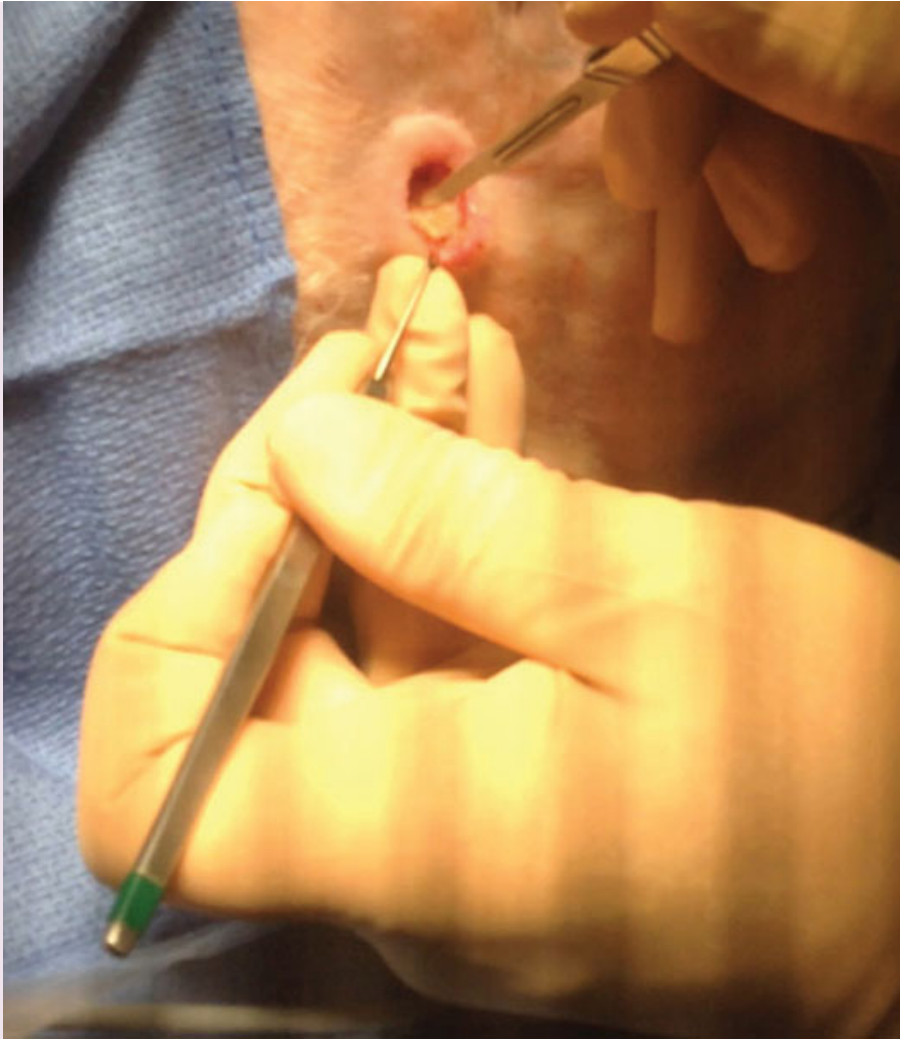
E. The negative control site is sutured with an intradermal 5-0 monocryl and a 5-0 fast-absorbing gut on the surface.



F. The LM is removed with a 15-C scalpel to the level of the adipose plane.



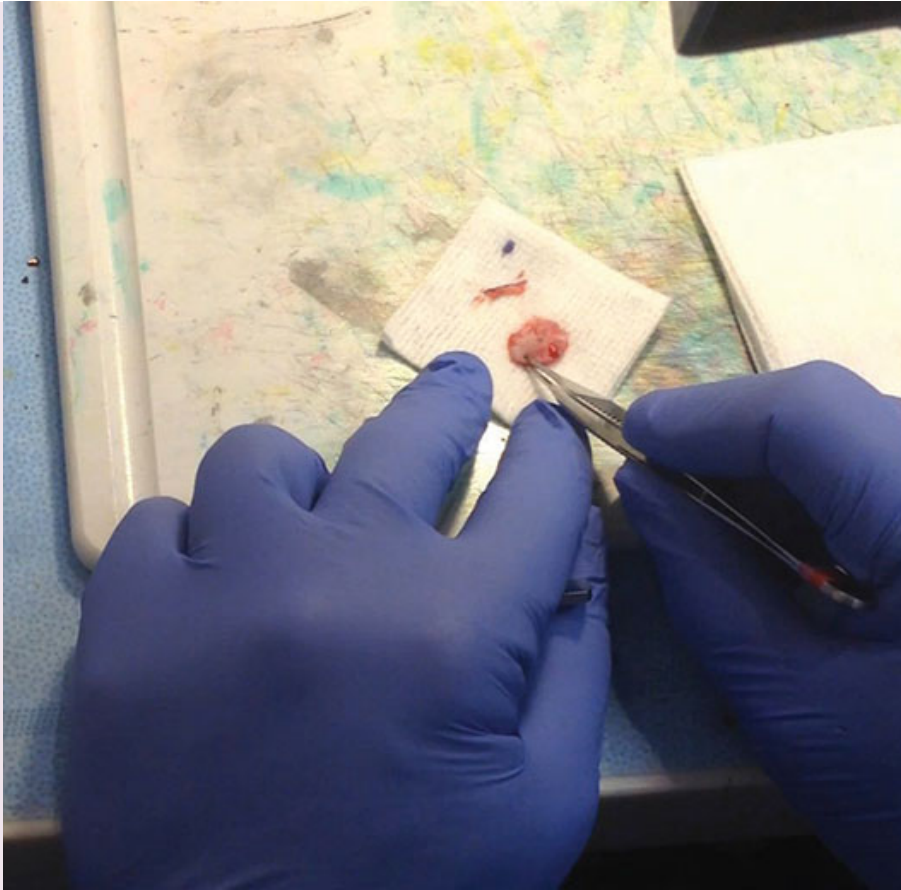
G. Undermining is performed 360 degrees around the LM surgical defect and hemostasis achieved with electrocautery.



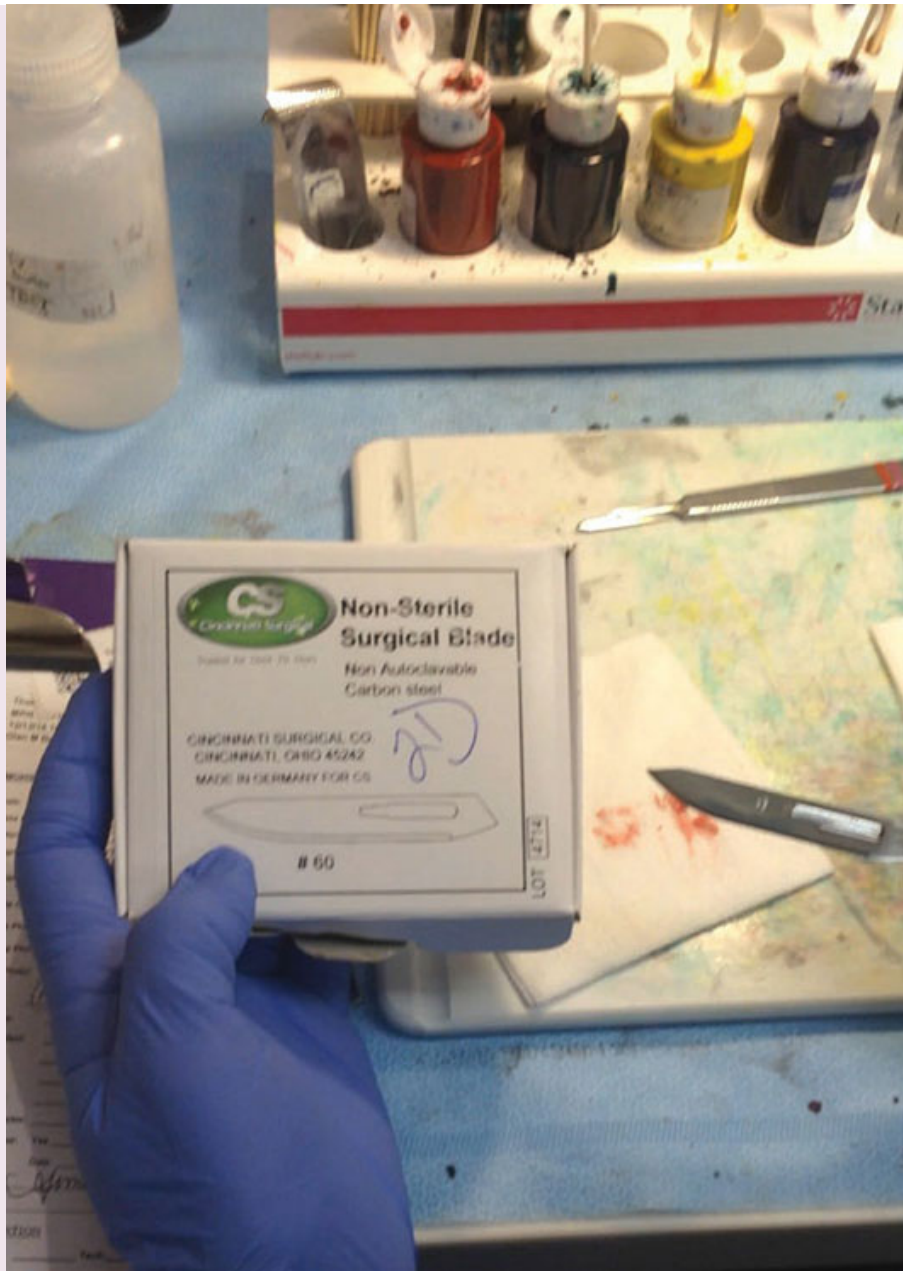
H. A plication traction suture is placed deep to the dermis to reduce tension on the intradermal sutures. An intradermal suture is then placed to allow for skin stretching during the laboratory processing time for the frozen sections and immunostaining.



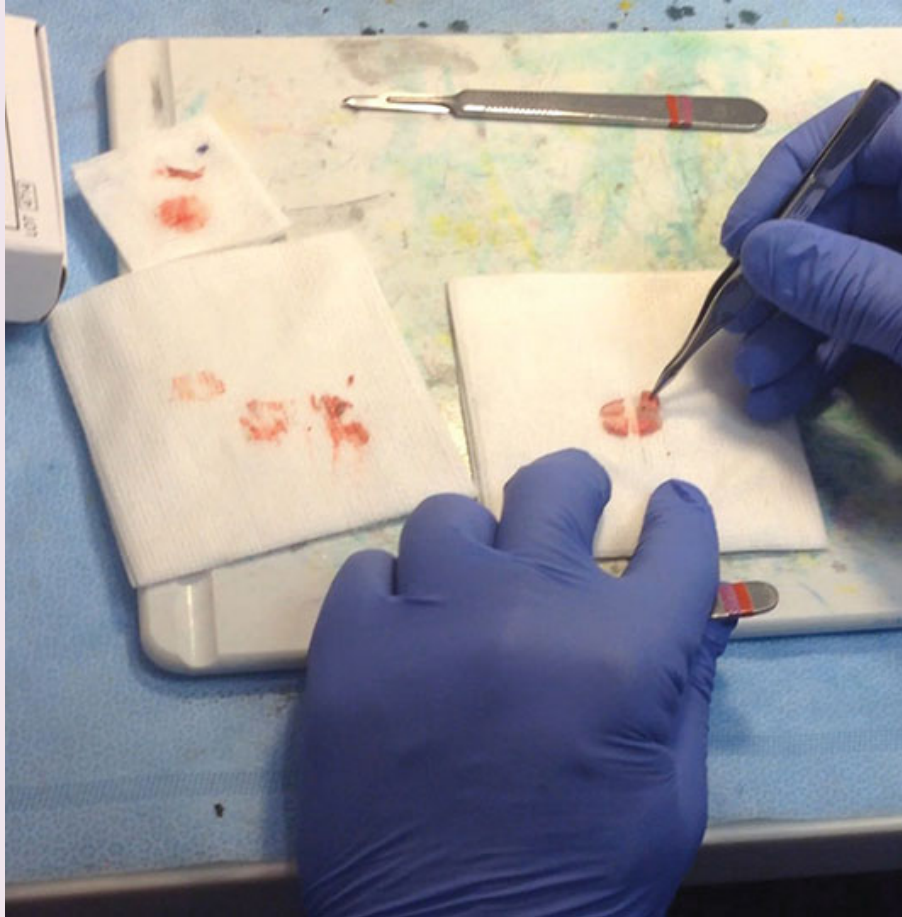
- I. The specimen is taken to the laboratory and defatted and thinned with scissors to facilitate the cutting of en face vertical sections.



J. The specimen is quadrisectioned with a dissecting blade.



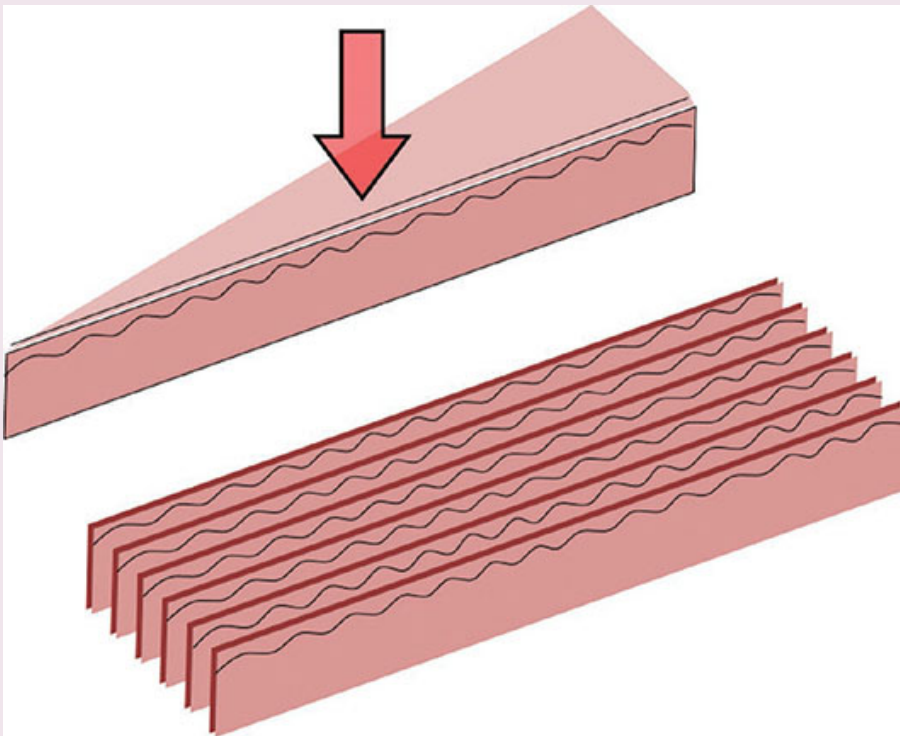
K. The perimeter of each quadrant is inked with its own color and then radial pie wedges are cut in about 3-mm widths. The first pie wedge of each quadrant is marked with black ink at the tip, so it can be identified as the first pie wedge as the specimens are viewed under the microscope in clockwise fashion.



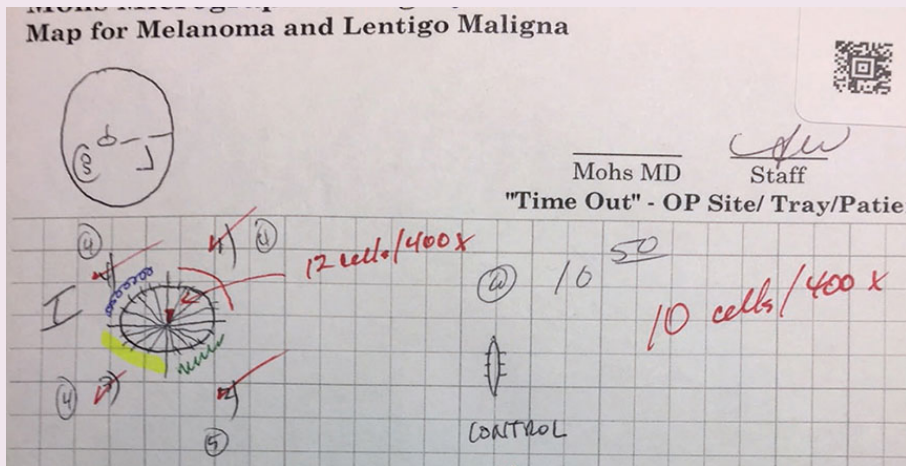
L. The pie wedges are laid down on the cutting chucks in clockwise order on their sides to allow for vertical en face sectioning in the cryostat.



M. The pie-wedge radial sections are cut with vertical en face sections and stained with H&E, Mart-1, and SOX10.



N. The specimens are viewed under the microscope and a comparison of melanocyte density is made between the LM specimen and the negative control. In this patient, the melanocytosis seen centrally in the first quadrant had a density of 12 melanocytes/400 $\times$ compared to 10 melanocytes/400 $\times$ in the negative control which is not a difference great enough to judge as “residual LM.”



O. Once negative histologic margins have been confirmed, the defect is closed primarily.



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CHAPTER 32 Histopathology for Mohs Micrographic Surgery

Teo Soleymani
Sumaira Z. Aasi



SUMMARY

- The Mohs surgeon must become expert at interpreting tangential sections and distinguishing normal structures from tumor.
- This may be challenging in certain situations depending on slide quality, section quality, and tumor subtype.

Beginner Tips



- An experienced technician is vital in the preparation of high-quality slides for evaluation.
- Aggregates of BCC may be distinguished from adnexal structures by peripheral palisading and retraction artifact.
- Examining multiple step sections may be helpful.
- Look closely at lymphocytic aggregates, as they often surround tumor nests.

Expert Tips



- Histopathologic interpretation of certain tumor subtypes, such as infiltrative BCC, may be challenging.
- These tumors should be differentiated from syringomas, desmoplastic trichoepitheliomas, and microcystic adnexal carcinomas.

Don't Forget!



- The differential diagnosis for SCCIS (and occasionally SCC) includes actinic keratosis, extramammary Paget's disease, inflamed seborrheic keratosis, verruca, pseudoepitheliomatous hyperplasia, and normal tangential sectioning of the epidermis.
- With moderate-to-poorly differentiated SCCs, perineural invasion is of concern.

Pitfalls and Cautions



- SCC may appear as single-cell infiltrates, which can be difficult to distinguish on frozen sections without the aid of immunohistochemical stains.
- There may be areas of focal necrosis, and often there is a prominent inflammatory lymphocytic (or lymphohistiocytic) infiltrate surrounding the malignant cells.

Patient Education Points



- Mohs surgery is unique in that one physician acts as both surgeon and pathologist.
- Educating patients regarding the complexity of the process, and the logistics behind tissue processing, may ameliorate stress regarding wait times between stages.

Billing Pearls



- If a lesion is biopsied for the first time on the day of Mohs surgery and a frozen section interpretation is made on the tissue, CPT code 88331 should be utilized with modifier 59.
- Billing for immunohistochemical stains is in addition to standard Mohs layer billing, and is generally billed on a per-specimen basis with code 88342 for the first antibody followed by 88341 for each additional antibody. If multiple separately identifiable antibodies are applied to the slide, use one unit of 88344.

CHAPTER 32 Histopathology for Mohs Micrographic Surgery

INTRODUCTION

Intraoperative histopathology is the cornerstone of Mohs micrographic surgery. The fundamental challenge for the Mohs surgeon is the accurate histologic identification and differentiation of benign versus malignant processes, as the goal of Mohs surgery is both to eradicate the cancer while concomitantly maximally conserving surrounding healthy tissue.

Often, features such as dense inflammation, chronic actinic damage with background solar elastosis, scar tissue, transected follicles, and other normal or benign cutaneous structures make differentiating benign versus malignant structures very challenging.

NORMAL ANATOMY

The skin consists of three distinct layers: the epidermis, the dermis, which is further divided into the superficial papillary and deeper reticular layers, and the subcutaneous fat.

The epidermis generally consists of four layers, with the exception of acral skin, which has an additional layer. The layer closest to the dermis is known as the basal layer or the *stratum basalis*, which consists of a single layer of slightly basophilic cuboidal cells with a relatively high nuclear-to-

cytoplasmic ratio. This basal layer is separated from the dermis by the *basement membrane zone*, a critical and highly specialized interface that allows for communication and anchoring of different cell types within the skin. Above the basal layer lies the spinous layer or *stratum spinosum*, which consists of cells with prominent intercellular connections, giving them a “spiny” shape. Above that lies the granular cell layer or the *stratum granulosum*, which consists of flat cells filled with stippled, coarse basophilic granules. The final layer consists of the cornified or keratinous layer, known as the *stratum corneum*. This layer is the most superficial and consists of anuclear cells typically arranged in a “basket-weave” pattern. In addition to the four layers mentioned above, there exists an additional fifth layer in acral skin, known as the *stratum lucidum*. This layer lies just underneath the stratum corneum and consists of pale, amorphous cells.

The dermis is comprised of a superficial section, known as the *papillary dermis*, and a deeper section, known as the *reticular dermis*. The papillary dermis contains a network of collagen and elastic fibers attached to and just underneath the basement membrane zone. The reticular dermis contains more dense bundles of collagen, small- to medium-sized blood vessels, and nerves, and extends to the subcutaneous fat. The subcutis, or subcutaneous fat layer, is composed of lobules of adipocytes separated by fibrous septae. Within the subcutis exist more abundant perforating blood vessels, nerves, and lymphatics.

Skin thickness varies depending on the region of the body. In addition, the skin contains numerous adnexal structures, such as hair follicles, sebaceous glands, eccrine and apocrine glands, as well as neurovascular bundles that vary in number and appearance based on anatomic location ([Fig. 32-1](#)). These adnexal structures can provide important clues as to the anatomic location of the body: for example, the presence of numerous small vellus hair follicles rooted superficially in the dermis may suggest facial skin, or the presence of apocrine glands, is suggestive of axillary or genital skin. In addition, certain dermal and subcutaneous features, such as the presence of striated skeletal muscle, or the presence of chronic actinic damage in the form of solar elastosis (seen as fragmented amorphous clumps of basophilic elastic fibers), can also provide clues as to the anatomic location and site.

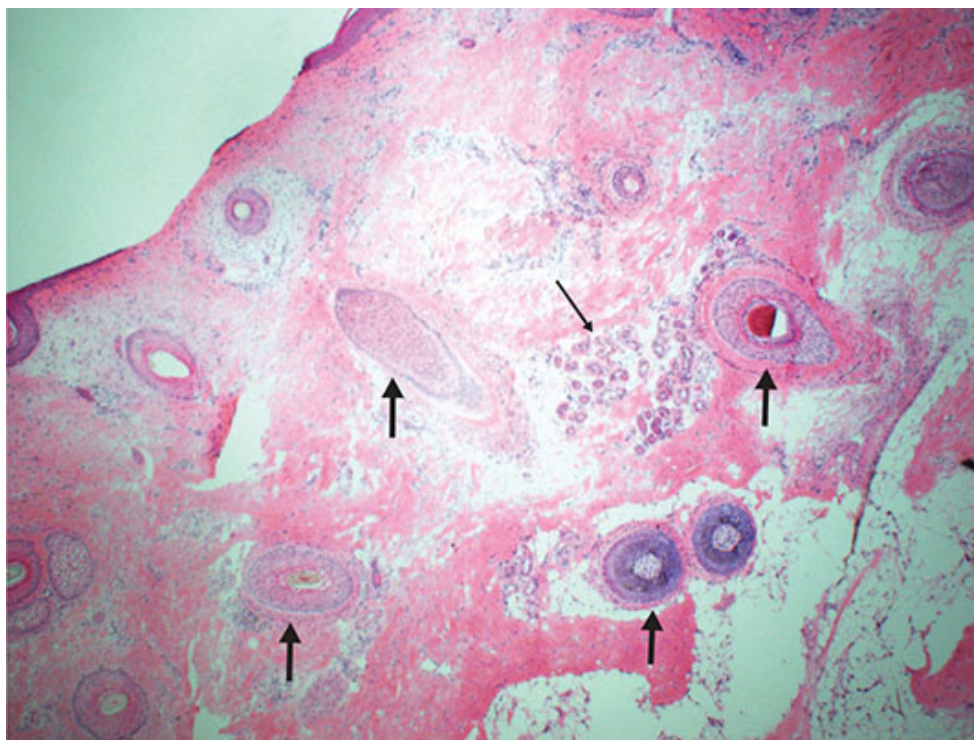


Figure 32-1. Mohs section of normal skin demonstrating hair follicles cut on cross section and longitudinally.

COMMON TUMORS TREATED WITH MOHS MICROGRAPHIC SURGERY

Basal cell carcinoma

Basal cell carcinoma (BCC) is the most common malignant cutaneous neoplasm encountered with Mohs micrographic surgery. This cancer is composed of aggregates of basophilic cells that form a variety of shapes depending on the histologic subtype. In general, tumor cells have large, elongated, oval-shaped nuclei, and are characteristically basophilic, with little cytoplasm. Notably, there is a lack of marked atypia or mitoses. Within the aggregates, the basophilic cells display characteristic peripheral palisading of the nuclei (essentially a lining up of the nuclei parallel to each other).

Between and surrounding the basophilic tumor aggregates, there exists a distinctive fibromyxoid or mucinous stroma. Retraction artifact, another key

feature of BCCs, is the formation of clefts or clear spaces created from tissue processing. These clefts separate tumor aggregates from the surrounding stroma. Peripheral palisading and retraction artifact are two common histologic characteristics of BCC that are helpful in identifying tumor aggregates. This also helps differentiate BCC from similar-appearing adnexal structures or tumors. Necrosis may be seen in the center of large tumor aggregates, and individual necrotic tumor cells are sometimes seen. Neoplastic aggregates often have a surrounding lymphocytic inflammatory infiltrate, and there is usually a background of solar elastosis within the surrounding dermis.

In addition to the aforementioned histologic features seen in the vast majority of BCCs, there are additional characteristic findings unique to each histologic subtype of BCC as discussed below.

In *superficial BCCs*, small buds of basaloid cells extend downward from the underside of the epidermis and hair follicle epithelium into the superficial dermis (Fig. 32-2). In *nodular BCCs*, basaloid aggregates of various size and shapes are present in the dermis (Figs. 32-3 and 32-4). In *micronodular BCC*, the basaloid tumor aggregates are smaller and often diminish in size as they progress deeper in the dermis (Fig. 32-5).

Infiltrative BCC is often deeply infiltrative and poorly circumscribed (Fig. 32-6). Spiky, angulated basaloid tumor aggregates are interspersed haphazardly between the normal structures in the dermis, often without clear demarcation between tumor and surrounding stroma. The fibromyxoid stroma is usually not present (and may even appear overly fibrotic) and there is lack of the characteristic peripheral palisading in the tumor aggregates. Where it is common to find an epidermal connection with nodular and micronodular BCC in at least some histologic sections of the specimen, epidermal connections are often absent with infiltrative BCC. Variably, a dense lymphocytic infiltrate may be seen, and perineural invasion may be present as well.

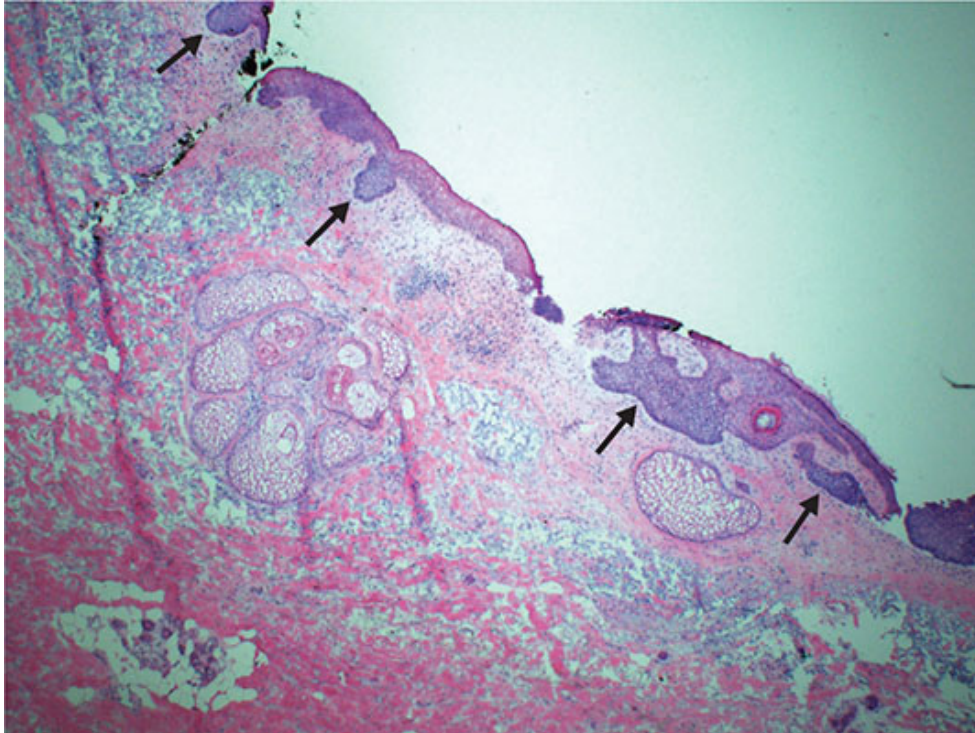


Figure 32-2. Superficial BCC. The neoplastic aggregates are “budding” off the basal layer of the epidermis (*black arrows*) and have a slightly more blue/basaloid color than the adjacent epidermis. Note the retraction artifact and the mucinous stroma.

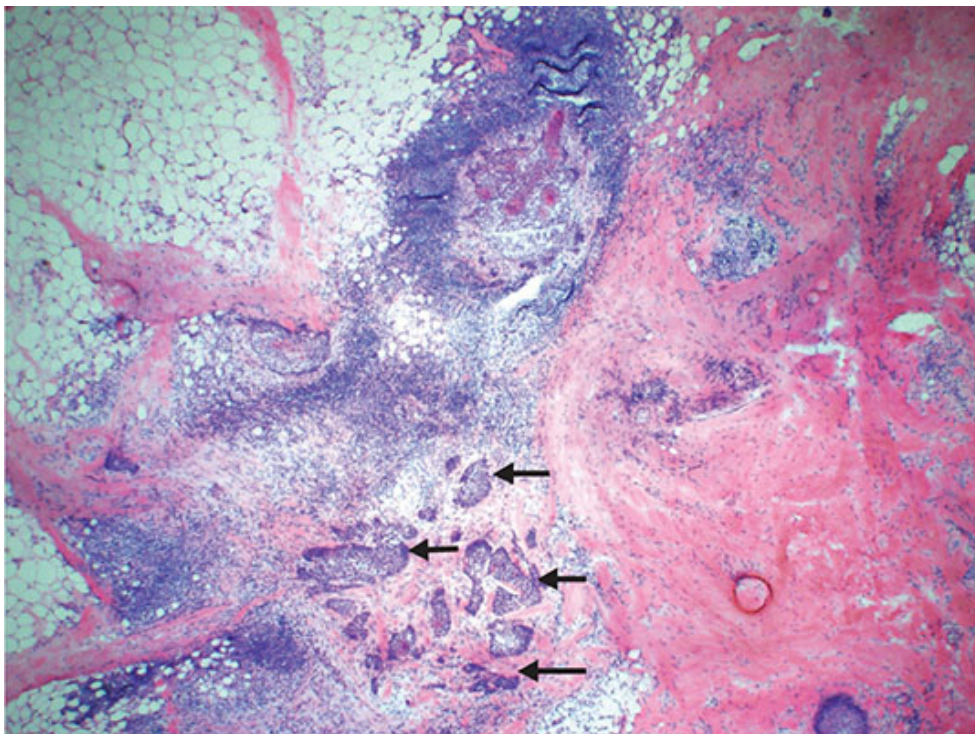


Figure 32-3. Nodular BCC and keratinizing BCC. At low-power magnification, note the variably sized nodular neoplastic aggregates composed of basaloid cells with palisading nuclei (*black arrows*). There are inflammatory lymphocytic infiltrates adjacent to and surrounding the neoplasm.

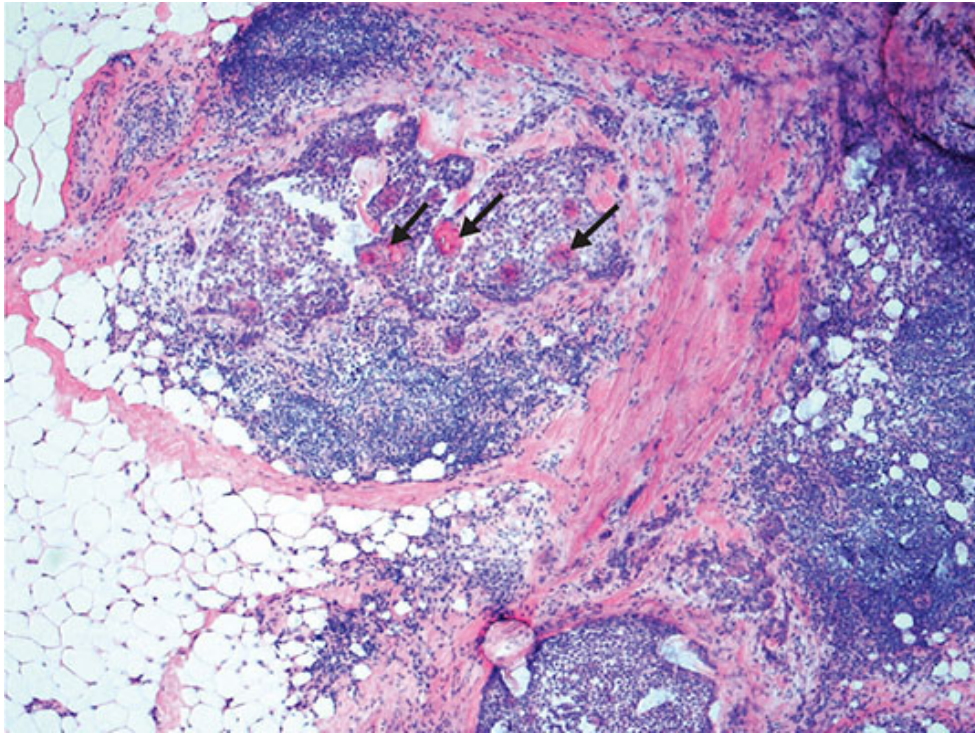


Figure 32-4. Nodular and keratinizing BCC. At higher-power magnification, note the keratinization occurring within the neoplastic aggregates (*black arrows*). This subtype of BCC is alternatively referred to as basosquamous carcinoma.

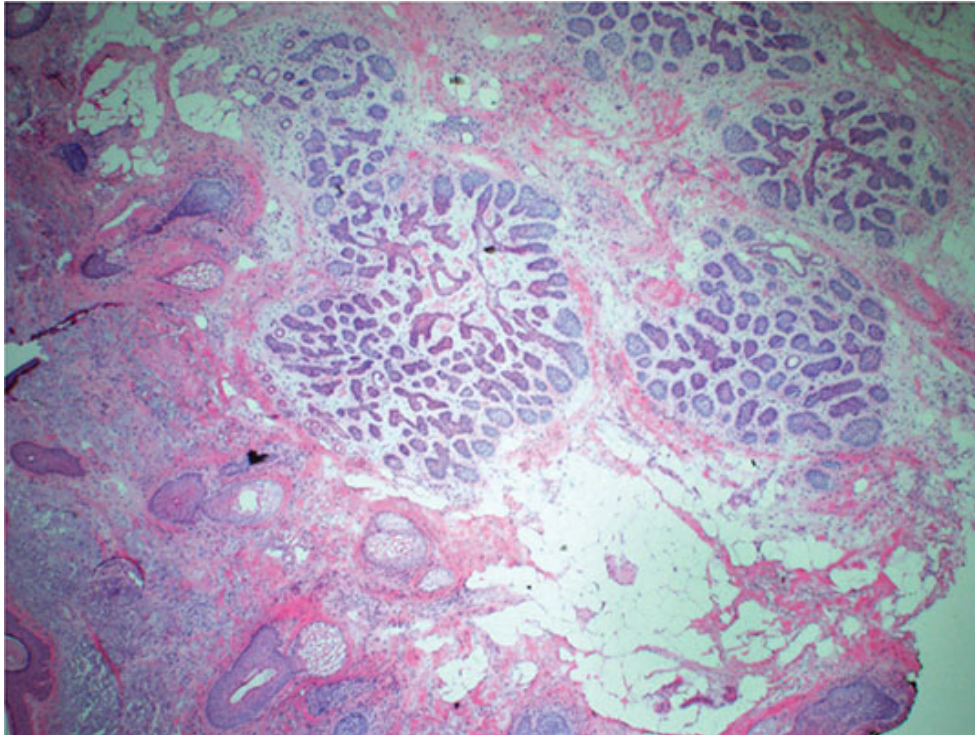


Figure 32-5. Micronodular BCC.

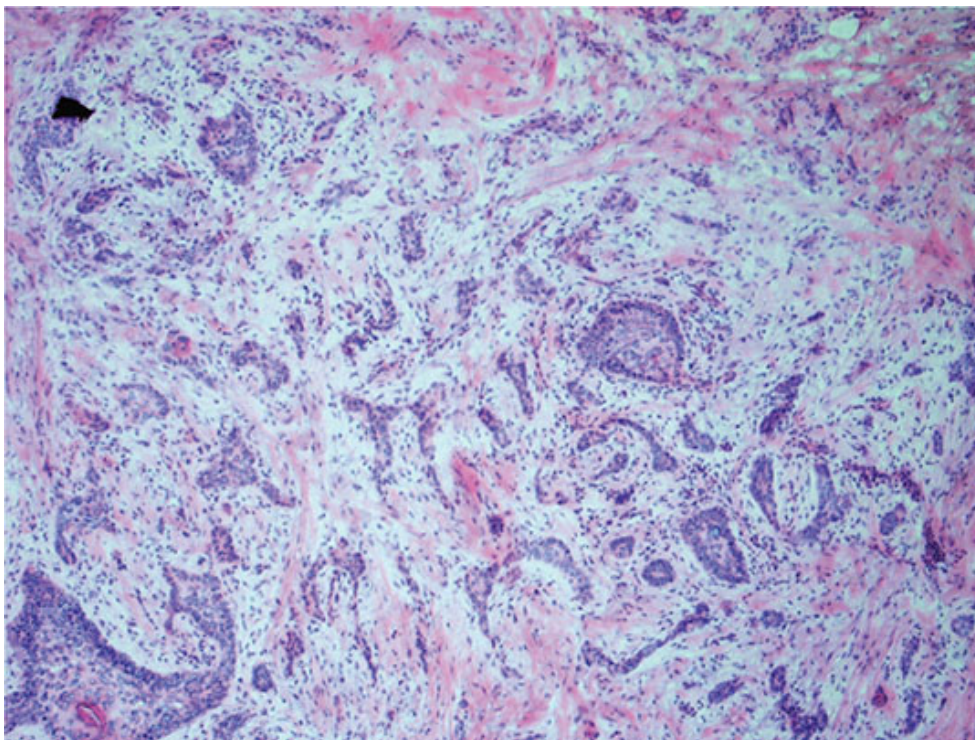


Figure 32-6. Infiltrative BCC demonstrating angulated cords and strand of basaloid cells. In this BCC, peripheral palisading is still appreciated as is mucinous stroma surrounding the neoplastic aggregates.

Importantly, in the majority of BCCs, more than one histologic subtype may be seen within a clinically solitary tumor (Fig. 32-7).

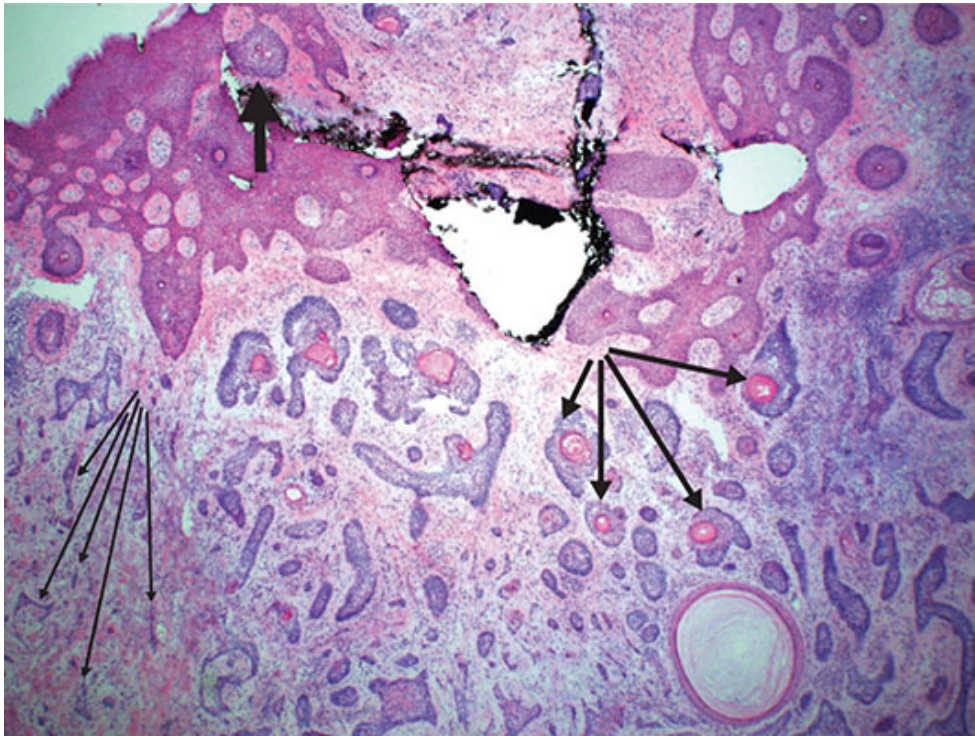


Figure 32-7. Mixed subtype BCC with superficial (*thick black arrow*), nodular, keratinizing (*medium black arrow*), and infiltrative (*thin black arrow*) features.

With superficial, nodular, and micronodular BCCs, the challenge for the Mohs surgeon is often to distinguish normal adnexal structures, particularly hair follicles that are transected at various levels and angles from neoplastic aggregates (Figs. 32-8 and 32-9).

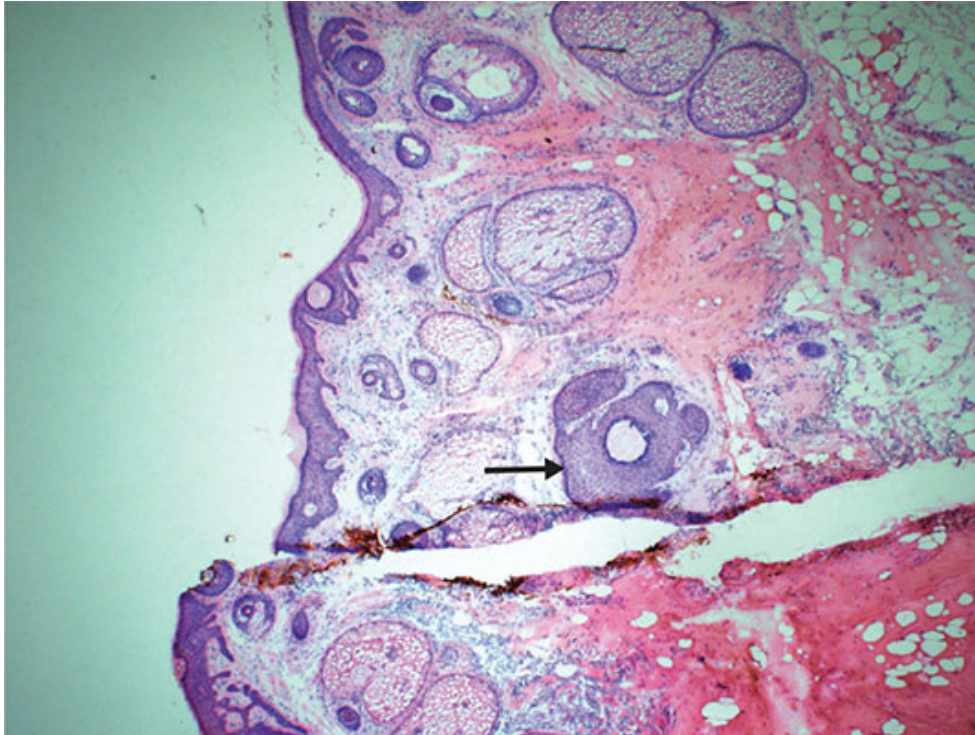


Figure 32-8. The differential diagnosis of a BCC includes tangential sectioning of a normal or aberrant hair follicle, as seen here (*black arrow*). Since BCCs are thought to be derived from germinal matrix cells of primordial hair follicles, histologic features such as palisading basaloid cells are present in both neoplastic aggregates and normal hair follicles. The lack of retraction artifact, cytologic atypia, nuclear pleomorphism, and absence of mitoses helps to differentiate the two.

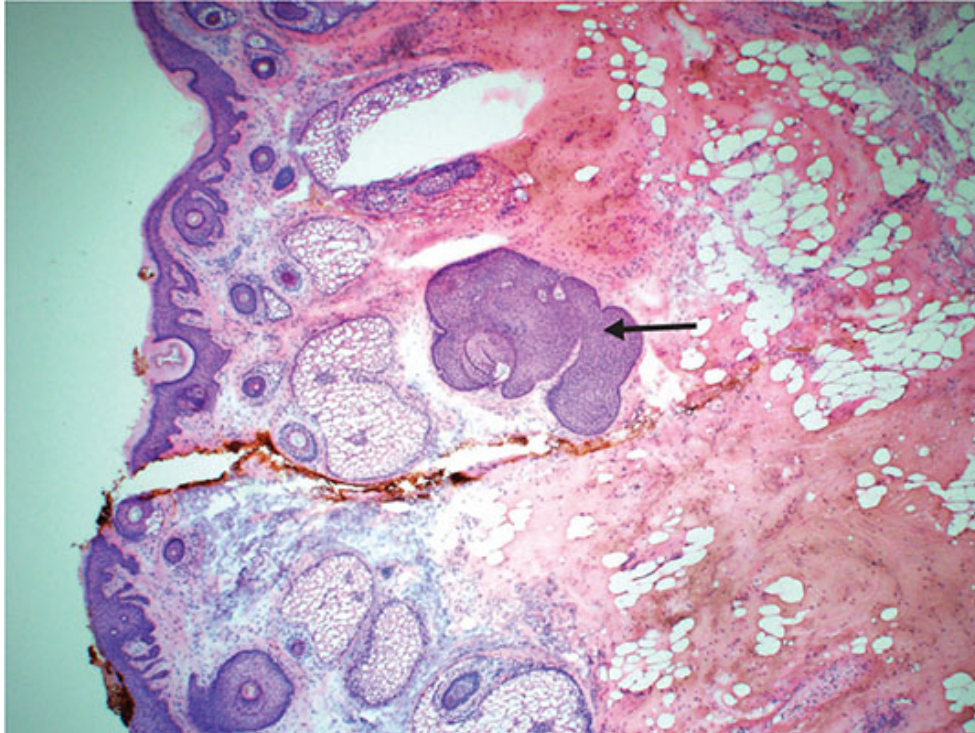


Figure 32-9. Another example of a tangentially sectioned and possibly aberrant hair follicle that can be mistaken for a nodular BCC (*black arrow*).

With infiltrative BCCs, this challenge also exists, along with the additional possibility that the spiky angulated “paisley-tie”- or “tadpole”-shaped basaloid aggregates are also seen in syringomas, desmoplastic trichoepitheliomas, and microcystic adnexal carcinomas (MACs).

Histologically, syringomas are composed of small, oval, “tadpole”-shaped aggregates that are often well demarcated, limited to the upper dermis, and have duct-like structures with monomorphous eosinophilic secretions in their lumina. Additionally, there is no clefting or retraction artifact seen with the aggregates in syringomas.

Desmoplastic trichoepithelioma is a tumor of follicular origin. Histologically, the tumor is small, well-circumscribed, often symmetric, plate-like, and confined to the papillary or superficial reticular dermis. Characteristically, the basaloid aggregates show evidence of follicular differentiation, and cystic structures with calcification may be present. A dense collagenous stroma surrounds the tumor aggregates without clefting or retraction space between them and the surrounding stroma. Perineural invasion and mitotic figures are absent.

Microcystic adnexal carcinoma (MAC) is histologically composed of angulated aggregates, cords, and strands of basaloid neoplastic cells. It is usually poorly circumscribed, asymmetric, and deeply infiltrative, often involving the subcutaneous fat and underlying skeletal muscle. Additionally perineural invasion is frequent and prominent. MACs demonstrate eccrine differentiation, and the presence of ductal structures help to differentiate them from infiltrative BCCs.

Pigmented BCCs are similar to nodular BCCs with foci of prominent melanin deposition. There may also be focal pigment incontinence, with melanophages seen in the dermis. Notably, there is no proliferation or nesting of melanocytes in the superficial dermis.

In *keratinizing BCCs*, the tumor aggregates display irregular shapes with areas of squamatization and keratin pearl formation. The squamatized cells may be enlarged and eosinophilic.

Other, less common subtypes of BCC include infundibulocystic and fibroepithelioma of Pinkus, and adenoid type. *Infundibulocystic BCCs* demonstrate differentiation toward the follicular infundibulum. They are often well circumscribed, with eosinophilic strands of squamous epithelium interspersed with basaloid buds in branching and anastomosing aggregates. Horn cysts are often present. Infundibulocystic BCCs may closely resemble basaloid follicular hamartomas histopathologically.

In *fibroepithelioma of Pinkus*, thin anastomosing strands of basaloid cells are seen attached to the epidermis and embedded in a background of ample fibromyxoid or mucinous stroma. Duct formation is often visible within the strands.

In *adenoid BCCs*, basaloid aggregates of neoplastic cells form small islands or strands in a lace-like pattern. There are clear, eccrine gland-like spaces in the middle of the islands (hence the “adenoid” pattern). Clefting or retraction artifact is often present, as is a fibromyxoid stroma.

Squamous cell carcinoma in situ

By definition, squamous cell carcinoma in situ (SCCIS) is limited to the epidermis, and invasion through the basement membrane is not seen (Figs. 32-10 through 32-13). Keratinocyte atypia involves the full thickness of the epidermis, which distinguished SCCIS from actinic keratosis, where the

atypia is confined to the lower levels of the epidermis. There is keratinocyte crowding in the basal layer, with disorganized, pleomorphic cells often arranged in a haphazard or “wind-blown” appearance. These crowded keratinocytes at the basal layer appear darker and more basophilic than surrounding healthy cells, with a high nuclear-to-cytoplasmic ratio, giving the lesion the “eyeliner sign.” The large pleomorphic neoplastic cells have hyperchromatic irregularly shaped nuclei and abundant eosinophilic glassy cytoplasm. Keratinocytes often appear vacuolated, and multinucleated cells may be present. There may also be individual necrotic keratinocytes. Mitotic figures are often seen, some of which are atypical. This is another distinguishing feature from actinic keratoses, which rarely display mitotic figures. The degree of cellular atypia may range from mild to severe. In addition, there is a lack of normal maturation of keratinocytes with ascent in the epidermis, as well as a lack of normal keratinization; the stratum corneum often demonstrates parakeratosis, as opposed to a normal basket-weave acellular keratin layer. In addition, due to this loss of maturation, the granular layer is often diminished or absent. Within the superficial papillary dermis, there is often a lichenoid or band-like lymphocytic infiltrate hugging the tumor along the dermal–epidermal junction.

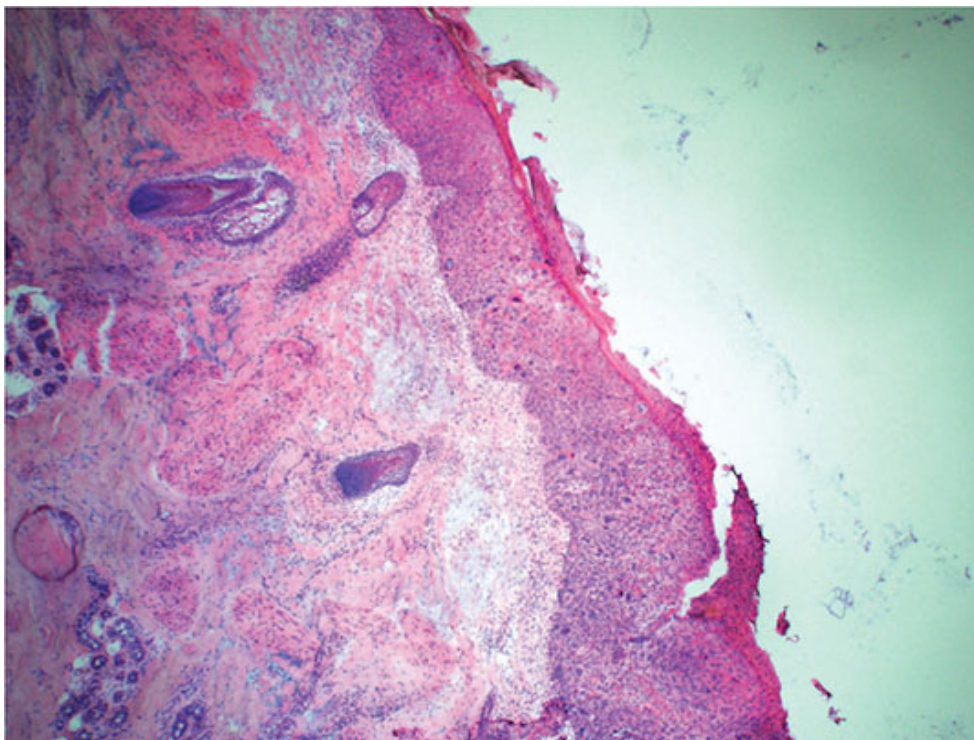


Figure 32-10. SCCIS. Full-thickness atypia of keratinocytes is present in the epidermis, giving the cells a “wind-blown” appearance. The atypia is limited to the epidermis and there is no invasion into the dermis. Hyperchromatic and pleomorphic nuclei are appreciated even at low power.

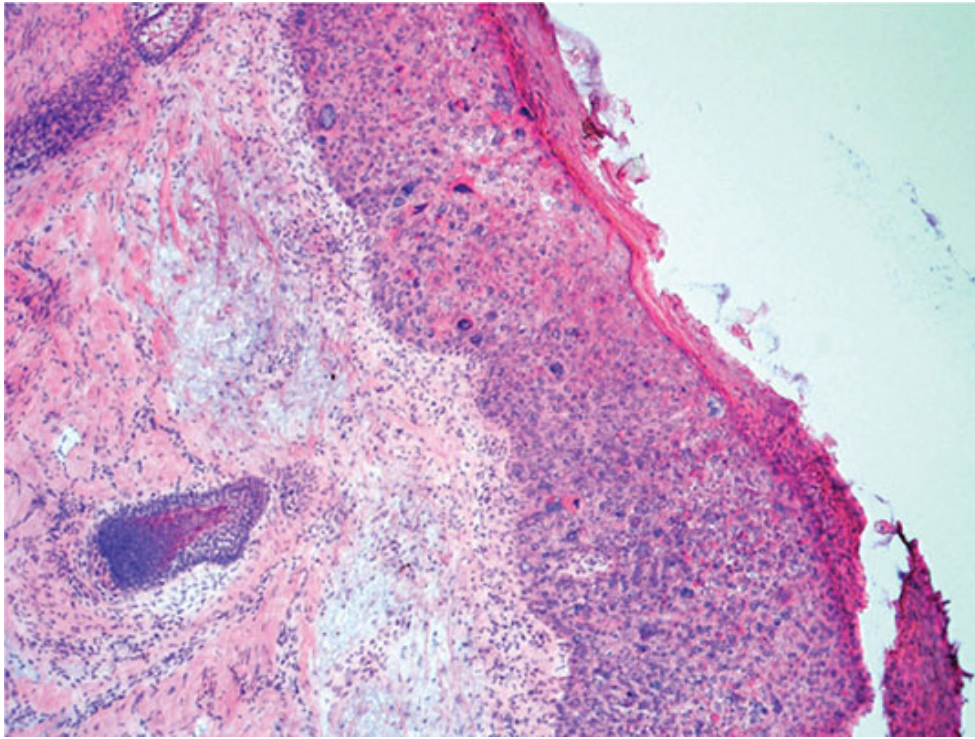


Figure 32-11. SCCIS. Large pleomorphic, hyperchromatic nuclei are present throughout the epidermis. Focal areas of pink keratinization are also present along with parakeratosis. Note the diminished granular layer. A lymphocytic inflammatory infiltrate in the superficial papillary dermis hugs the neoplastic process.

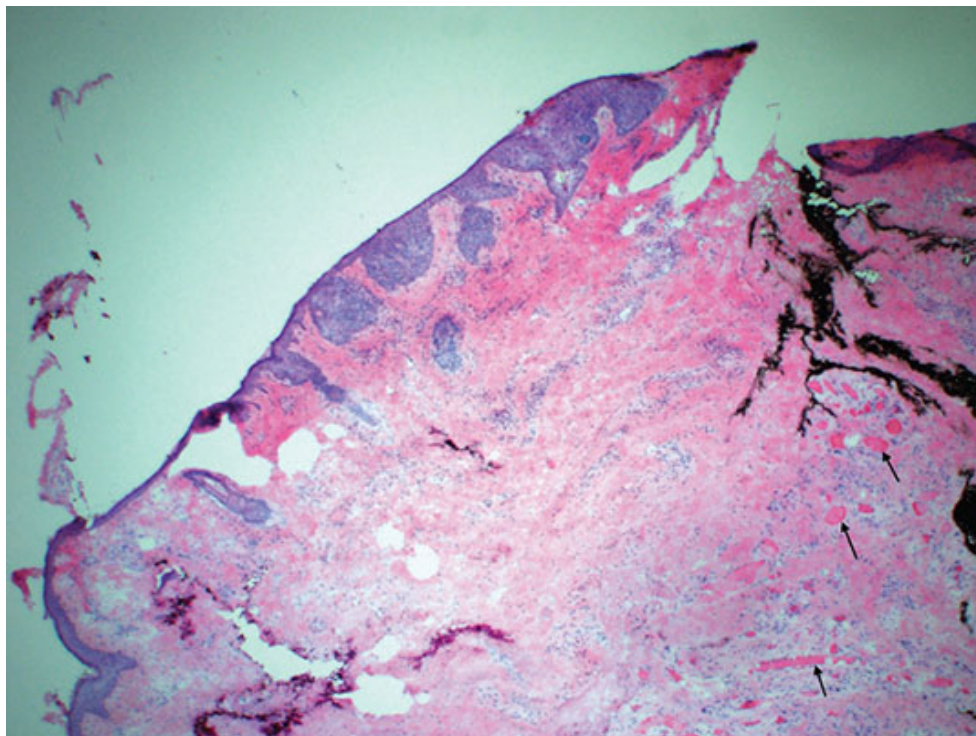


Figure 32-12. SCCIS, eyelid. Full-thickness atypia of keratinocytes limited to the epidermis, especially where the epidermis appears acanthotic. Skeletal muscle fibers below the reticular dermis are present (*black arrows*).

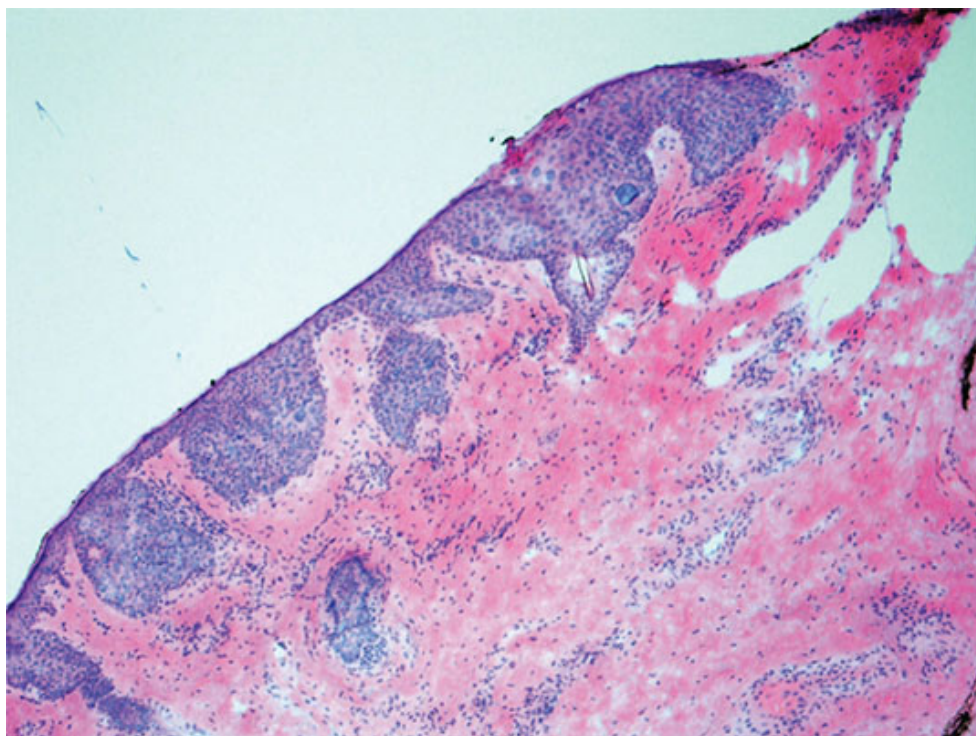


Figure 32-13. SCCIS, eyelid. Higher-power magnification demonstrating the pleomorphic and hyperchromatic nuclei and atypical keratinocytes.

The differential diagnosis for SCCIS (and occasionally SCC) includes actinic keratosis, extramammary Paget's disease, inflamed seborrheic keratosis, verruca, pseudoepitheliomatous hyperplasia, and normal tangential sectioning of the epidermis.

In *actinic keratosis*, there is a lack of full-thickness atypia of the epidermis, which is essential in differentiating this entity from SCCIS. The atypia is restricted to the lower portions of the epidermis. There are rarely mitotic figures, and keratinocyte atypia does not involve follicular structures.

With *inflamed seborrheic keratoses*, there are often horn cysts and pseudohorn cysts in the epidermis, with overlying parakeratosis and mild reactive atypia. There is often an inflammatory lymphocytic infiltrate in the superficial papillary dermis. Importantly, there is no invasion into the dermis, and the atypia, if any, does not involve the full thickness of the epidermis; mitoses are rare.

With *verruca*, the epidermis is acanthotic, and there is hypergranulosis. Koilocytes are often present in the upper epidermal layers. In addition, dilated capillaries may be seen in the dermal papillae. There is no true atypia of keratinocytes. In *verrucous carcinoma*, however, a low-grade HPV-driven carcinoma, the histologic findings more closely resemble those of SCC.

Extramammary Paget's disease is an intraepidermal adenocarcinoma thought to be of apocrine origin. The epithelioid neoplastic cells are large, vacuolated, and are scattered throughout the epidermis in a pagetoid or "buckshot" pattern type that fans outwards with ascent through the epidermis. The neoplastic cells have a low nuclear-to-cytoplasmic ratio with vesiculated nuclei, basophilic nucleoli, and abundant pale cytoplasm. Cells may also be present along the dermal–epidermal junction but can infrequently invade the dermis.

Pseudoepitheliomatous hyperplasia is often a reactive result of various processes; a healing biopsy wound is the most common scenario a Mohs surgeon would encounter. The proliferation of the epithelium may resemble SCC, though the aggregates are often composed of large, uniform keratinocytes with abundant eosinophilic cytoplasm. Atypia, if any, is often mild and reactive, and mitoses are rare. Importantly, the keratinocytes are

well differentiated, and no nuclear atypia, hyperchromasia, or pleomorphism is present. Horn cysts and keratin pearls may be present. The epidermis and regenerating epithelial aggregates are often angulated, jagged, uneven, or even sharply pointed. Deeper sectioning into the tissue block may be helpful in distinguishing this reactive phenomenon from SCC.

Occasionally, tangential sectioning of a normal epidermis when trying to cut en-face Mohs sections can be misleading for novice Mohs surgeons. The absence of true atypia, and the lack of hyperchromasia, pleomorphism, or mitotic figures, helps distinguish this processing artifact from SCC or SCCIS. In addition, the presence of dermal papillae projecting through an epidermis that contains normal maturing keratinocytes is another useful clue confirming tangential sectioning artifact (Figs. 32-14 and 32-15).

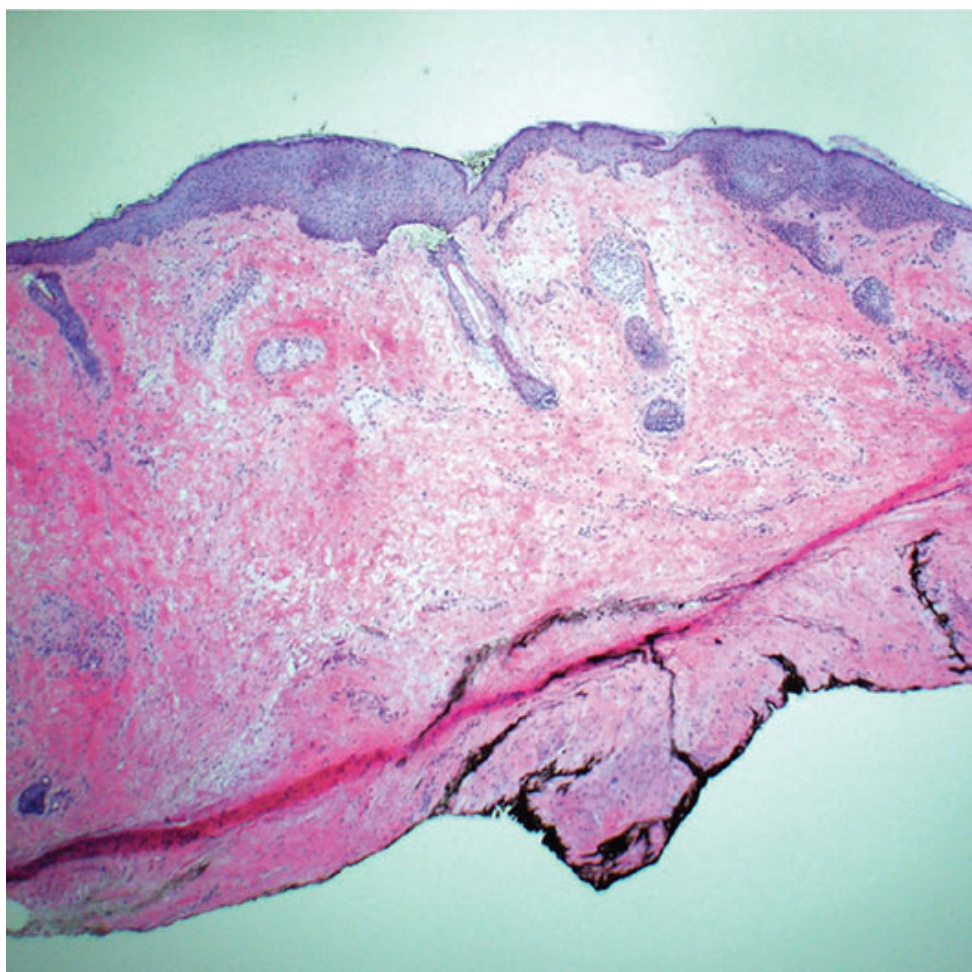


Figure 32-14. Tangential sectioning of normal epidermis. At lower power, this normal epidermis that was tangentially sectioned during processing can easily be mistaken for an SCCIS at quick glance.



Figure 32-15. Tangential sectioning of normal epidermis. Closer examination reveals the evident lack of cytologic atypia, nuclear pleomorphism, and mitoses. Normal keratinocyte maturation helps to differentiate this artifact from malignant process.

Squamous cell carcinoma

Squamous cell carcinoma (SCC) is the second most common malignant cutaneous neoplasm encountered in Mohs micrographic surgery. In SCCs, the irregular aggregates of atypical neoplastic keratinocytes arising from the epidermis invade into the dermis ([Figs. 32-16 to 32-19](#)).

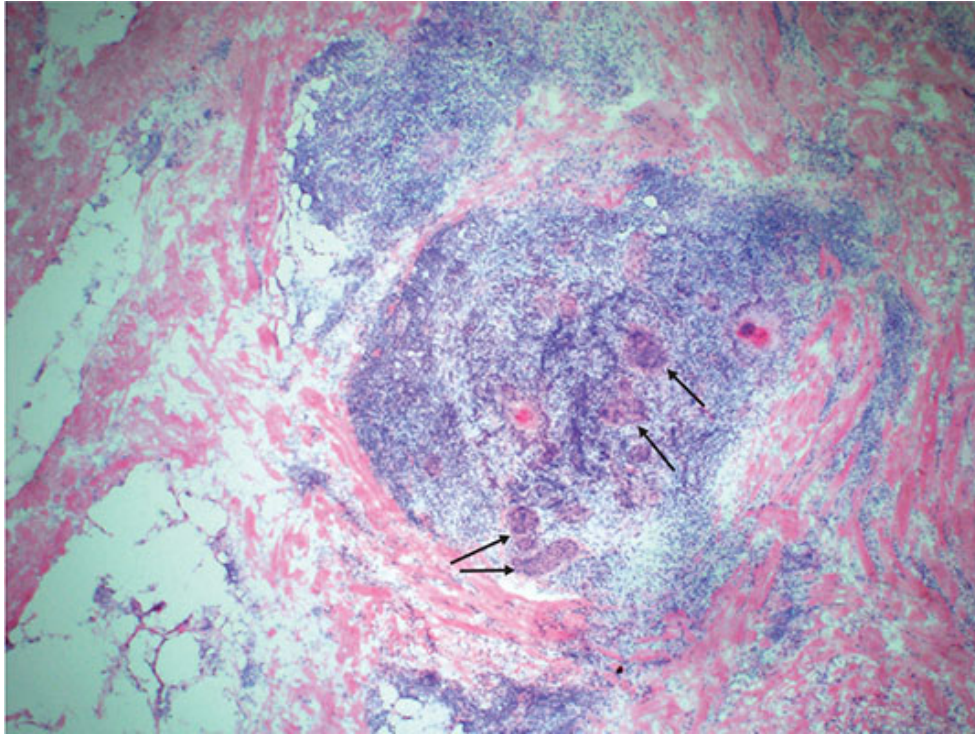


Figure 32-16. Well-differentiated SCC. Note the neoplastic aggregates (*thin black arrows*) surrounded by a dense lymphocytic infiltrate.

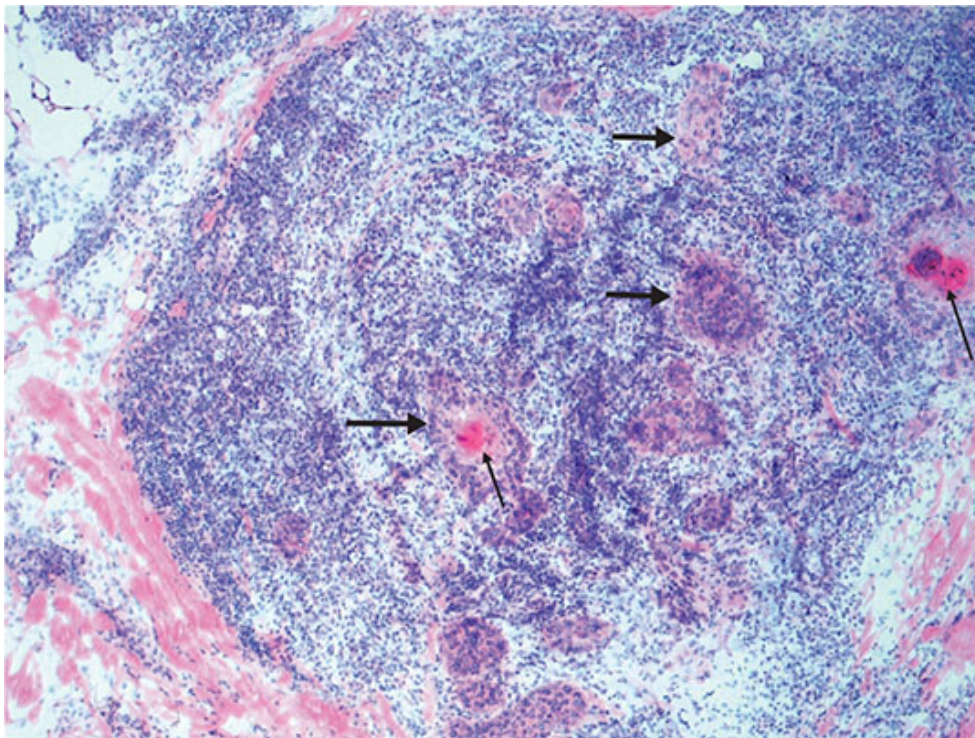


Figure 32-17. Well-differentiated SCC. At higher magnification, the moderate differentiation of this neoplasm is demonstrated by the presence of keratinization or “keratin pearl” formation (*thin black arrows*) adjacent to the tumor aggregates (*thick black arrows*).

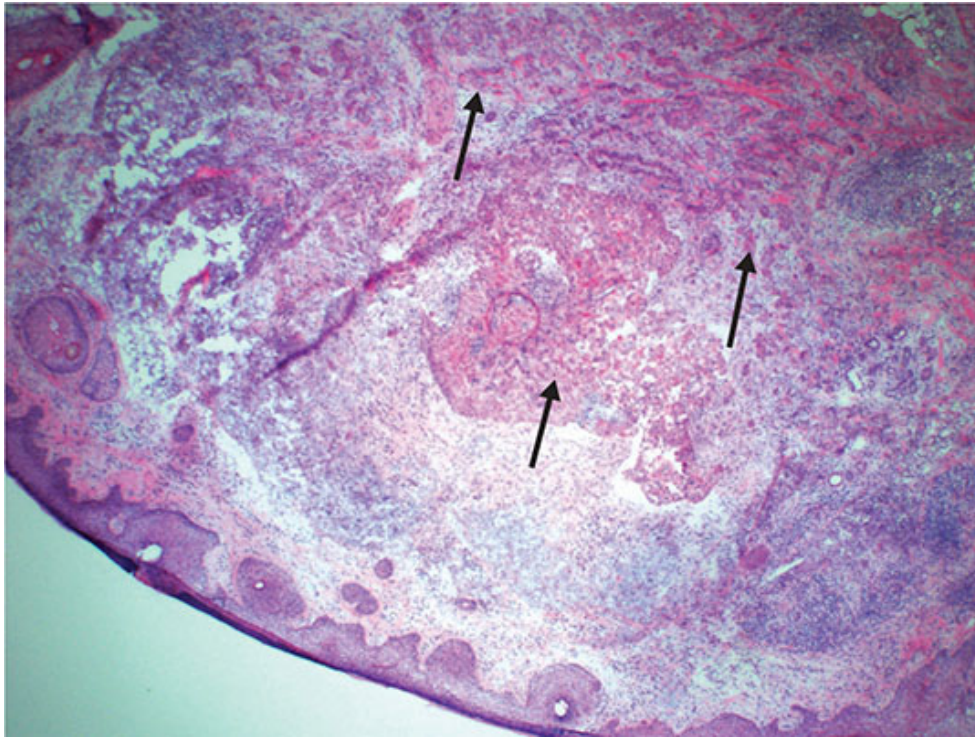


Figure 32-18. Moderately differentiated SCC. At low-power magnification, variably sized eosinophilic neoplastic tumor aggregates are present in the dermis (*black arrows*).

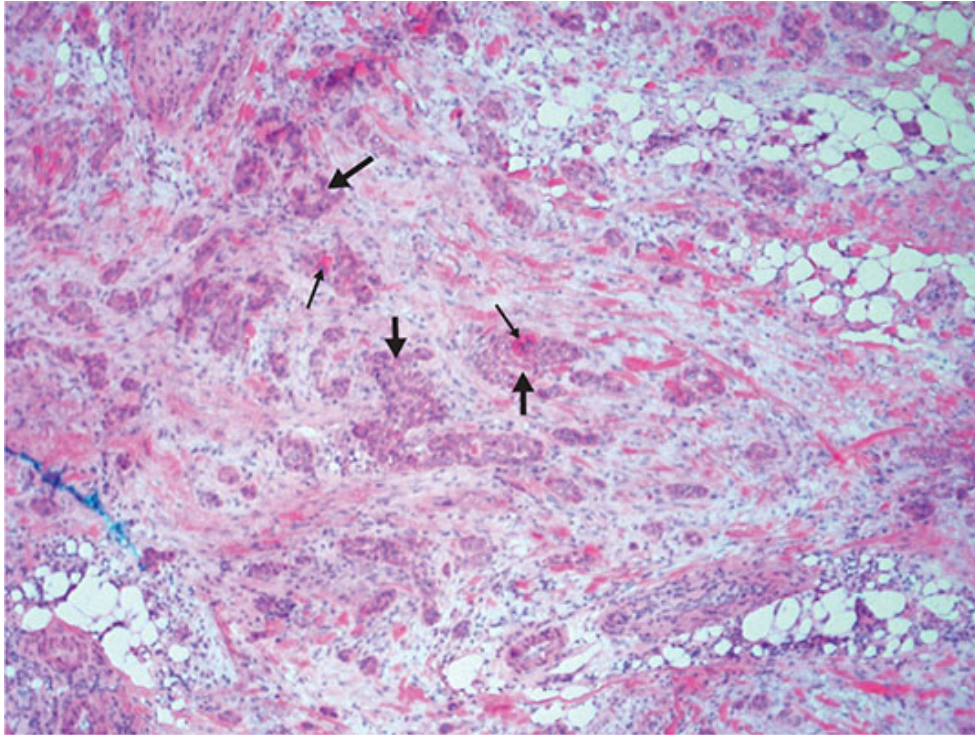


Figure 32-19. Moderately differentiated SCC. At higher-power magnification, note the moderate differentiation of the neoplastic aggregates (*thick black arrows*), with keratinization or “keratin pearl” formation (*thin black arrows*).

The aggregates of neoplastic cells are often poorly circumscribed and vary markedly in size and shape. Neoplastic keratinocytes have vesicular nuclei, darker prominent nucleoli, and abundant eosinophilic cytoplasm. Nuclear pleomorphism is common, with atypical hyperchromatic nuclei and large nucleoli. Dyskeratotic cells show pyknotic nuclei and homogenous, bright, glassy eosinophilic cytoplasm. There are an increased number of mitotic figures within the neoplastic aggregates, often many of which are atypical.

Depending on the degree of differentiation of the neoplasm, the neoplastic aggregates may contain cells that closely resemble keratinocytes and demonstrate signs of keratinization such as the presence of keratin pearls (concentric whorls of eosinophilic parakeratotic cells). In contrast, poorly differentiated tumors contain cells that are less epitheloid and less eosinophilic and lack keratin pearls (Figs. 32-20 to 32-23).

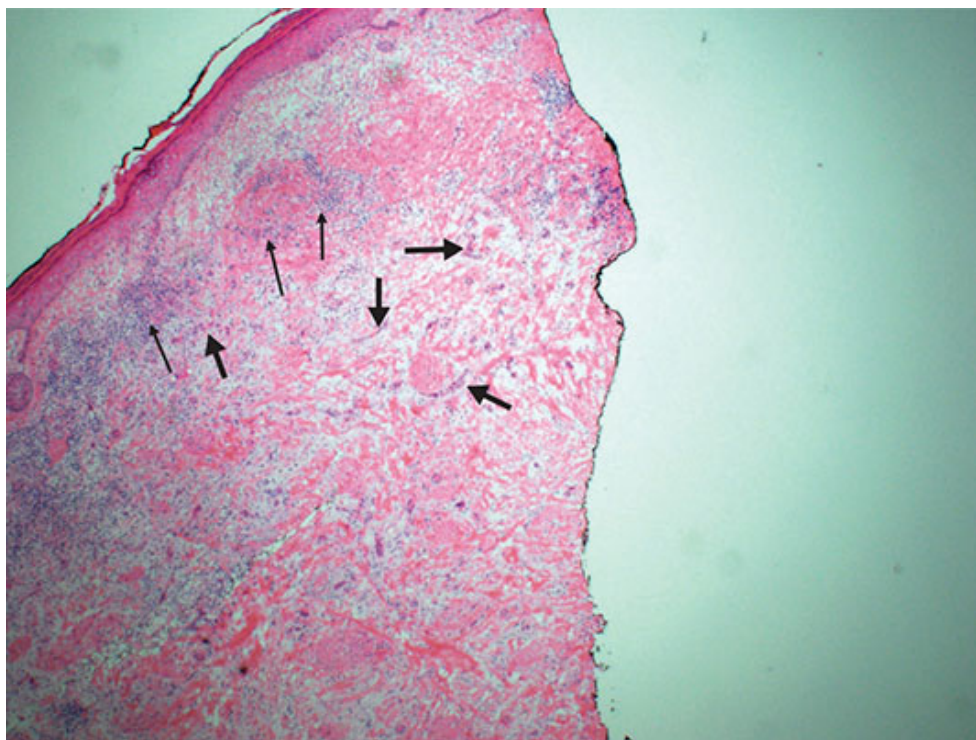


Figure 32-20. Poorly differentiated SCC. Note the subtle tumor aggregates within the dermis, many of which are one- to two-cell layers thick (*thick black arrows*). These can be easily overlooked, particularly in the setting of an inflammatory lymphocytic infiltrate (*thin black arrows*) that often accompanies SCCs.

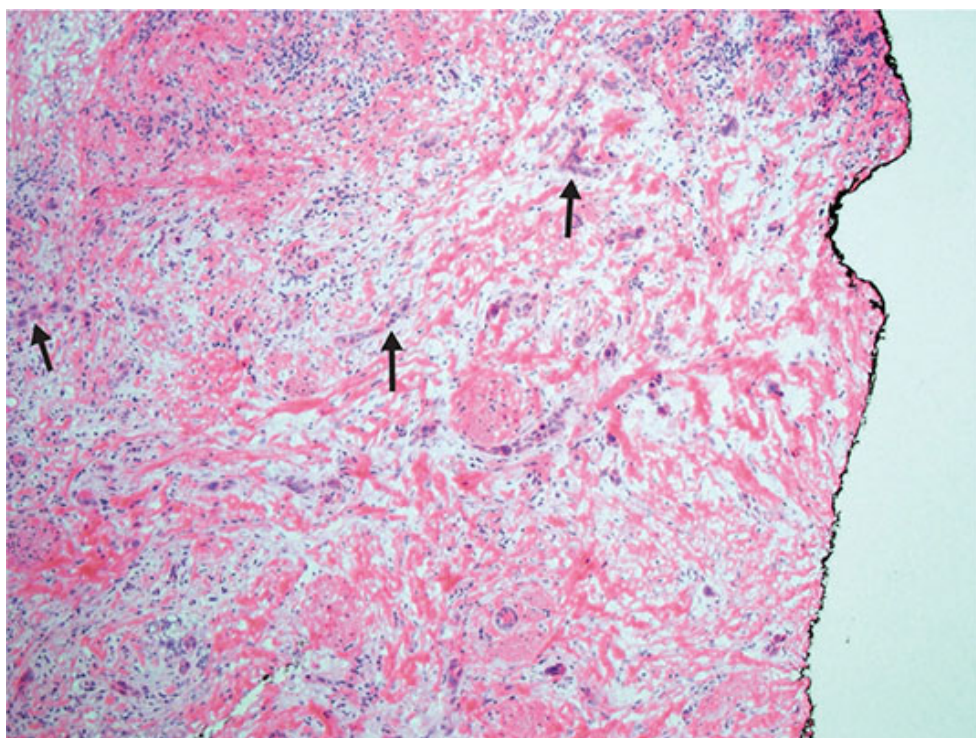


Figure 32-21. Poorly differentiated SCC. Higher-power magnification demonstrates the pleomorphic nuclei within the single-cell neoplastic strands and cords (*black arrows*).

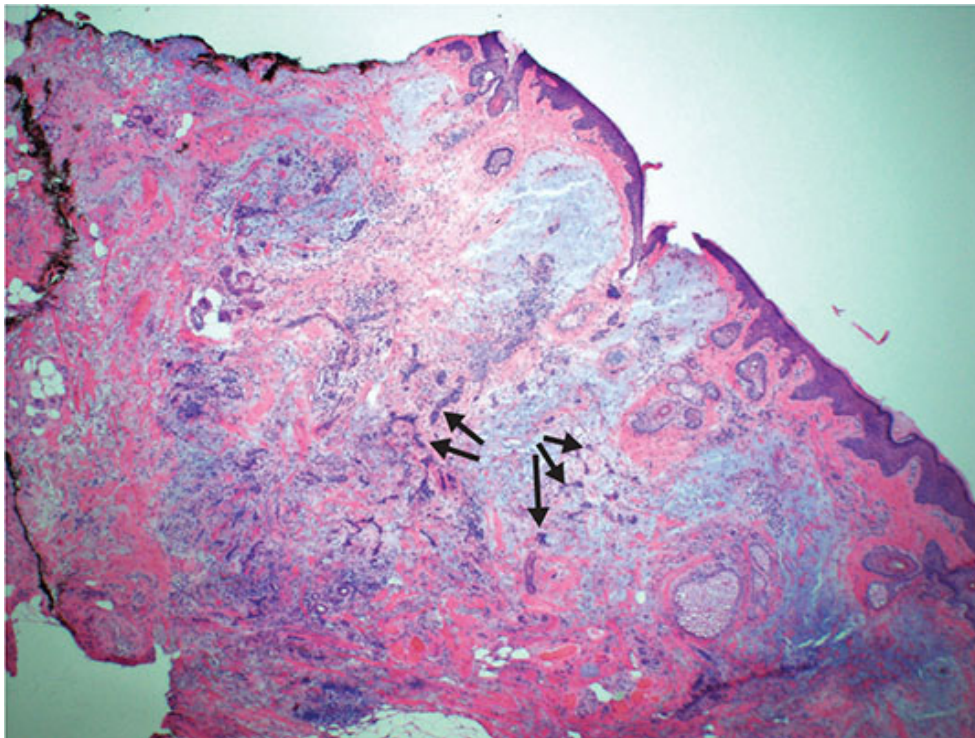


Figure 32-22. Poorly differentiated SCC. At low power, the irregular, angulated neoplastic aggregates (*arrows*) may resemble an infiltrative BCC. Note the background solar elastosis and inflammatory lymphocytic infiltrate intermixed within the tumor.

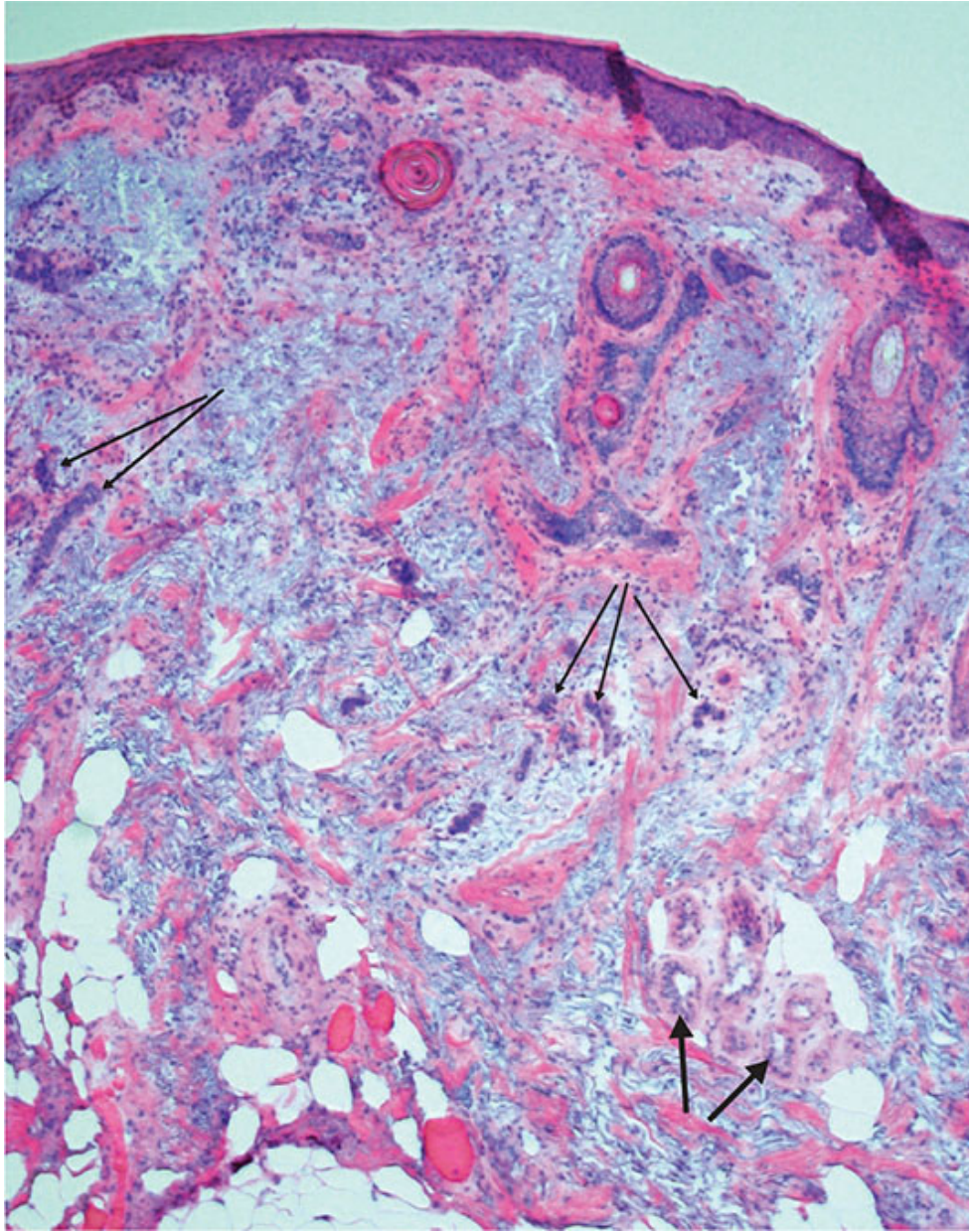


Figure 32-23. Poorly differentiated SCC. At higher power, the cells (*thin black arrows*) are poorly differentiated with hyperchromatic pleomorphic nuclei, and in contrast to infiltrative BCCs, there is no retraction artifact, palisading, or surrounding fibromyxoid stroma. Note the difference between normal eccrine glands (*thick black arrows*) and neoplastic tumor aggregates.

The aggregates may be composed of a few cells and can even appear as single-cell infiltrates, making them very challenging for the Mohs surgeon to distinguish on frozen sections without the aid of immunohistochemical stains. There may be areas of focal necrosis, and often there is a prominent

inflammatory lymphocytic (or lymphohistiocytic) infiltrate surrounding the malignant cells.

With moderate-to-poorly differentiated SCCs, perineural invasion is of concern. Malignant keratinocytes may surround and encircle nerves or invade the perineurium or endoneurium (Figs. 32-24 and 32-25), and perineural invasion should be suspected in any tumor that demonstrates inflammation around nerves. Additionally, lymphovascular invasion, although rare, is a poor prognostic factor, and challenging to recognize on histologic sections.

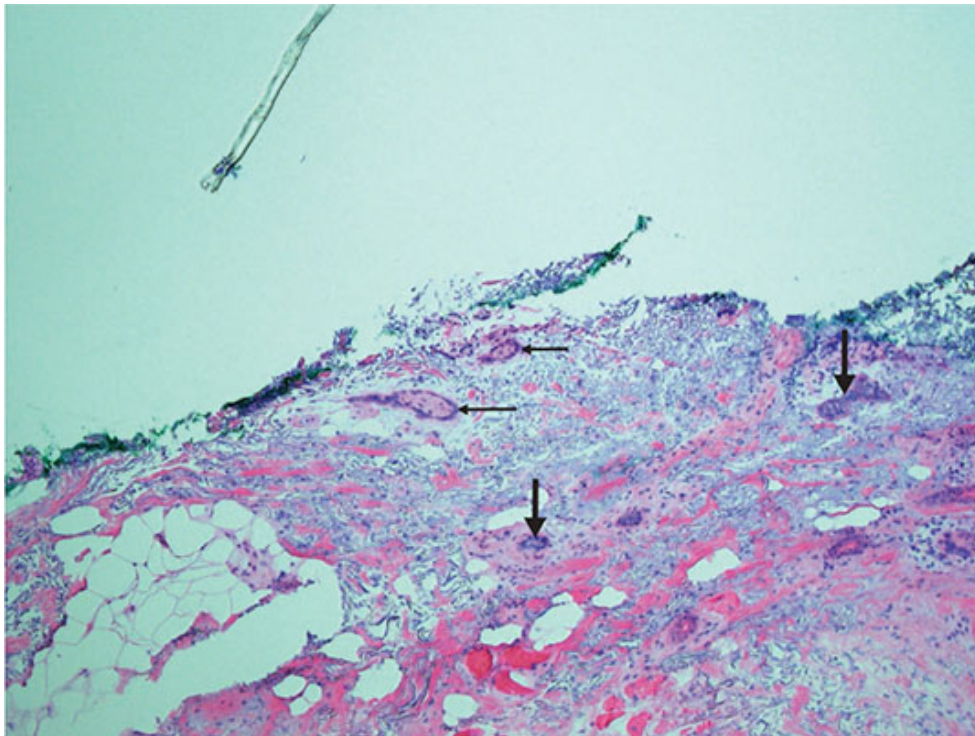


Figure 32-24. Perineural SCC. Poorly differentiated SCC (*thick black arrows*) demonstrating perineural invasion (*thin black arrows*).

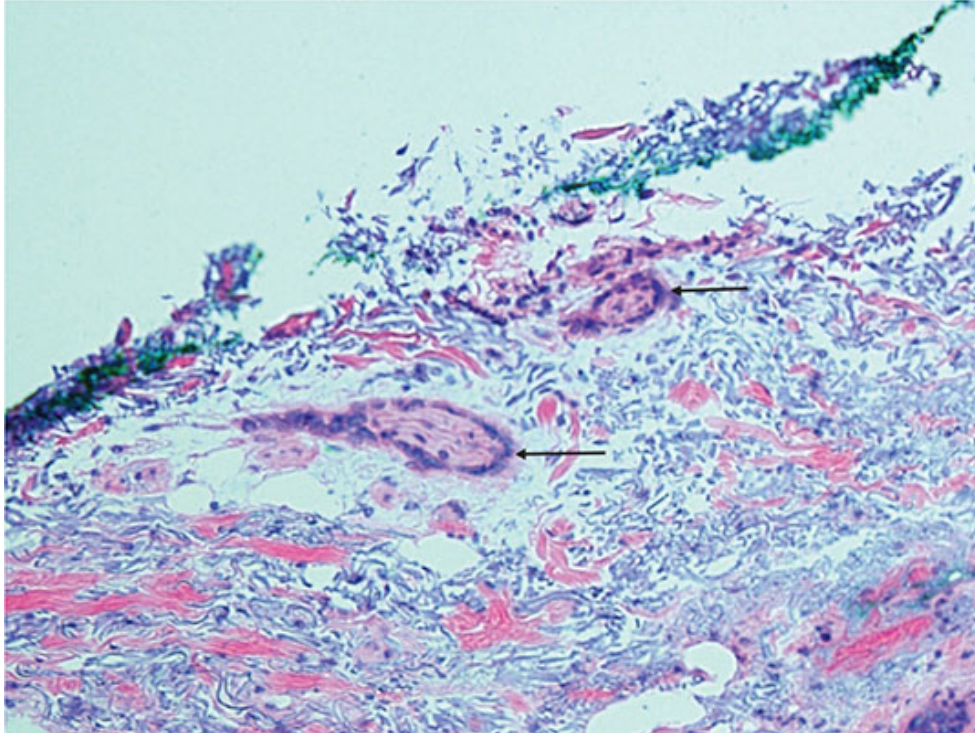


Figure 32-25. Perineural SCC at higher magnification.

In addition to these general histologic features seen in SCCs, several histologic subtypes demonstrate additional characteristic findings.

In *infiltrative SCCs*, the malignant cells are arranged in elongated strands, cords, or single cells that infiltrate deeply and haphazardly between collagen fibers within the papillary and reticular dermis (Fig. 32-26). There is a lack of keratinization, and connection with the epidermis is often subtle. There is often a scattered inflammatory lymphocytic infiltrate around the individual aggregates of neoplastic cells.

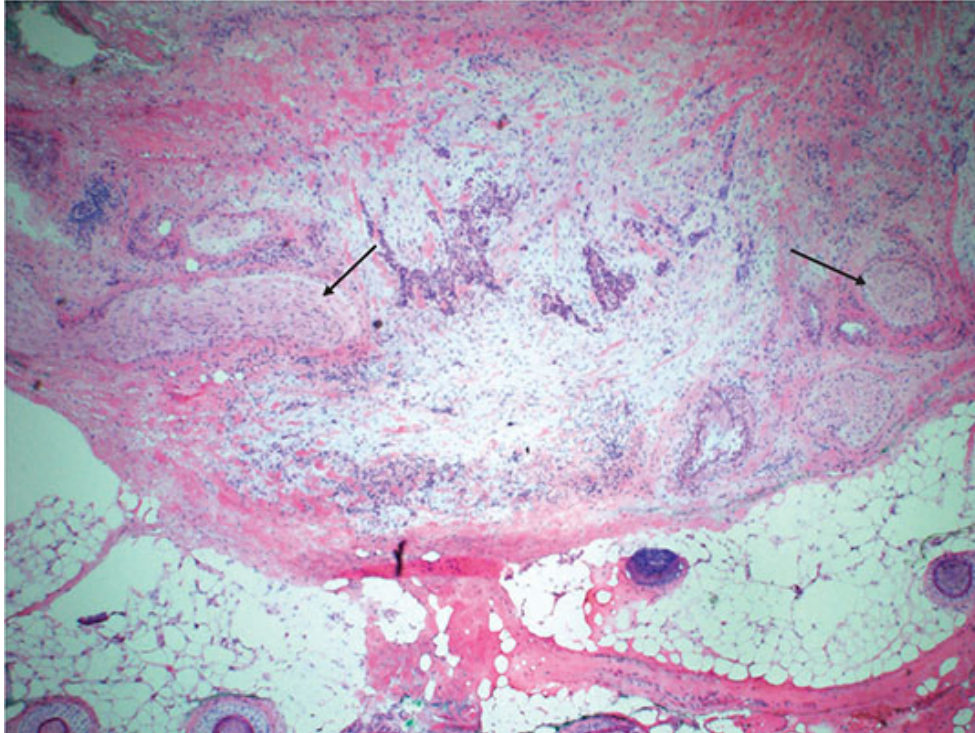


Figure 32-26. Another example of a poorly differentiated SCC, without perineural invasion, as demonstrated by uninvolved clean nerves cut longitudinally and on cross section (*thin black arrows*).

In *spindle-cell SCC*, the neoplastic epithelial cells take on a characteristic spindle shape; these cells form sheets or fascicles in a storiform or herringbone pattern invading into the dermis. Neoplastic cells have elongated, spindle-shaped nuclei, and bizarre, pleomorphic giant cells may also be present. Tumors often infiltrate deeply into the dermis; however, connection to the epidermis may still be present, which provides an important clue to the diagnosis and helps to differentiate spindle-cell SCC from other spindle-cell neoplasms.

In *acantholytic SCC*, there is acantholysis of the malignant neoplastic cells, creating pseudoglandular islands. The neoplastic epithelial cells often align around a space resembling a lumen that contains acantholytic atypical keratinocytes. Of note, the acantholytic cells and tumor islands may only be seen in a portion of the tumor. There may be focal keratinization, and acantholytic actinic keratosis may be seen directly adjacent to the tumor

Melanoma

The routine use of Mohs micrographic surgery for invasive malignant melanoma remains controversial, and is often reserved for unique situations such as acral and facial melanomas where tissue preservation is essential for functional outcome. However, in the setting of in situ disease, Mohs micrographic surgery for tumor extirpation has become increasingly accepted and utilized, with the aid of improved melanocytic immunohistochemical stains. Frozen sections must be cut thinner (in the order of 2 to 4 microns) in order to proficiently interpret melanoma in situ.

On routine hematoxylin and eosin staining, melanoma in situ demonstrates nested and confluent atypical melanocytes gathered along the dermal-epidermal junction. The lesions are often broad, especially in the case of lentigo maligna, in a background of solar elastosis. There may be pagetoid or “buckshot”-type spread of atypical melanocytes into the epidermis. The rete ridges are commonly effaced, and nonnested melanocytes often outnumber nested melanocytes. The nests, if there are any, vary in size and shape, and are often bizarre, elongated, or confluent. There is distinct asymmetry, and lateral borders are poorly defined. There may be a dense, lichenoid lymphocytic inflammatory infiltrate along the dermal edge of the lesion. Mitoses may be present, and there is often cytologic atypia.

In invasive malignant melanomas, poorly nested aggregates of atypical melanocytes extend beyond the dermal–epidermal junction into the dermis. The tumor is variably circumscribed with lateral asymmetry, and atypical melanocytes display a lack of normal maturation or dispersion with descent into the dermis. There is often prominent pagetoid or “buckshot” scatter into the epidermis. The rete ridges are commonly effaced, and non-nested melanocytes often outnumber nested melanocytes. Deep pigment may be present in melanocytic nests. The nests, if there are any, vary in size and shape, and are often bizarre, elongated, or confluent. There is often a lymphocytic inflammatory infiltrate at the base of the lesion, and plasma cells may be present as well. Mitoses, including deep mitoses, may be seen, and there is often cytologic atypia.

Historically, the utility of Mohs micrographic surgery for atypical melanocytic proliferations, including melanoma in situ, was limited given the poor diagnostic recognition of atypical melanocytes on frozen section. However, with the advancement of immunohistochemical stains and development of adequate staining techniques for frozen section tissue, the

resolution and diagnostic accuracy for atypical melanocytic proliferations have advanced greatly.

Currently, the most commonly used immunohistochemical stain used for intraoperative assessment of melanoma margins during Mohs micrographic surgery is the MART1 (Melan-A) stain. Immunohistochemical staining for MART1 is helpful in detecting both benign and malignant melanocytic proliferations, and has become the immunohistochemical stain of choice for the detection of malignant melanoma in situ using Mohs micrographic surgery. However, it is important to note that the MART1 antibody stain is a highly sensitive cytoplasmic stain; there is often significant background staining of melanocytes in the setting of chronic sun-damaged skin, and thus using MART1 to differentiate between benign and malignant melanocytic proliferations for tumor margin assessment may prove challenging. Additionally, MART1 does not stain desmoplastic melanomas. For a full discussion of Mohs surgery for melanoma in situ, see [Chapter 31](#).

Microcystic adnexal carcinoma

MAC is a malignant adnexal neoplasm that demonstrates eccrine differentiation. Clinically, it appears as a firm nodule or slow-growing plaque, most commonly on the face, with a greater predilection for women than men. Neoplastic cells are basaloid and uniform in shape, with monomorphous nuclei, a high nuclear-to-cytoplasmic ratio, and scant cytoplasm. The basaloid neoplastic aggregates form irregular, spiky, and angulated cords and strands traversing between collagen bundles. Often, the tumor aggregates are larger superficially and diminish in size with descent into deeper layers. Notably, the basaloid cords and strands may be very thin, and are sometimes comprised of just one cell layer, making the interpretation of frozen Mohs sections challenging. A dense hyalinized stroma, comprised of thickened collagen bundles, surrounds the neoplastic basaloid aggregates. Ductal structures are often present, and there is a lack of clefts or retraction artifact between tumor aggregates and surrounding stroma.

These histologic features may be similar to those found in infiltrative or morpheaform BCC, though with MAC the tumor is usually larger, poorly circumscribed, asymmetric, and deeply infiltrative, often involving the subcutaneous fat and underlying skeletal muscle. Additionally, MAC is considered a neurotropic tumor, and perineural invasion is common. The lack

of clefting, though also variable in infiltrative BCC, may also help to differentiate it from MAC. There is effacement and destruction of adjacent adnexal structures, which occurs less commonly in keratinocytic tumors. The stroma surrounding tumor aggregates is often sclerotic rather than fibromyxoid, as is the case with BCCs.

Dermatofibrosarcoma protuberans

Dermatofibrosarcoma protuberans (DFSP) is a fibrohistiocytic mesenchymal soft tissue tumor of intermediate malignant potential that has a marked tendency to recur, though it rarely metastasizes. It is believed that the cell of origin is an undifferentiated mesenchymal cell in the dermis, with fibroblastic, muscular, and neurologic features. Histologically, DFSPs are poorly delineated, with an infiltrative growth pattern. The tumor is comprised of bland, monomorphous, spindle-shaped neoplastic cells with elongated nuclei arranged in fascicles in a storiform or herringbone pattern (Figs. 32-27 and 32-28). Mitotic figures are rare, as is necrosis within the tumor. The tumor often involves the full thickness of the dermis, extending into the subcutaneous fat, and occasionally underlying skeletal muscle. Extension and infiltration of the spindled neoplastic cells into the subcutaneous fat form a honeycomb or lace-like pattern involving the fat lobules, and septal fibrosis is frequently seen. A Grenz zone between the tumor and overlying epidermis is often present. Adnexal structures are often effaced within the area occupied by the tumor. Importantly, DFSPs are positive for CD34 and negative for factor 13A, differentiating them from cellular dermatofibromas.

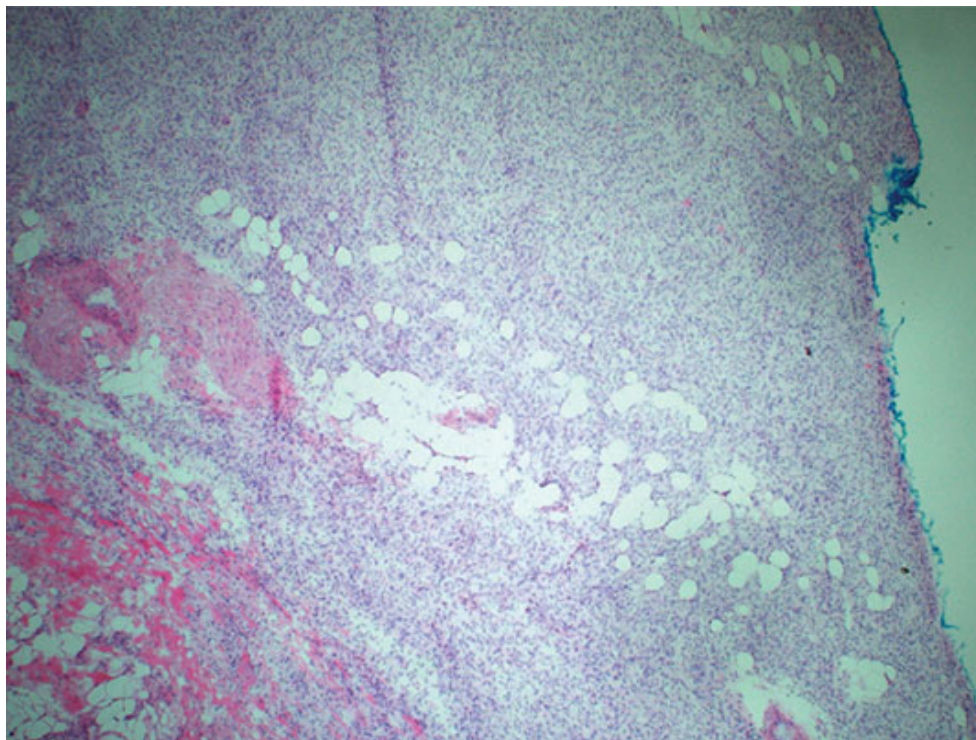


Figure 32-27. Dermatofibrosarcoma protuberans. The tumor is poorly circumscribed, infiltrative, and there is effacement of normal adnexal structures. Infiltration of the neoplastic cells into the subcutaneous fat forms a honeycomb pattern involving the fat lobules, often with septal fibrosis.

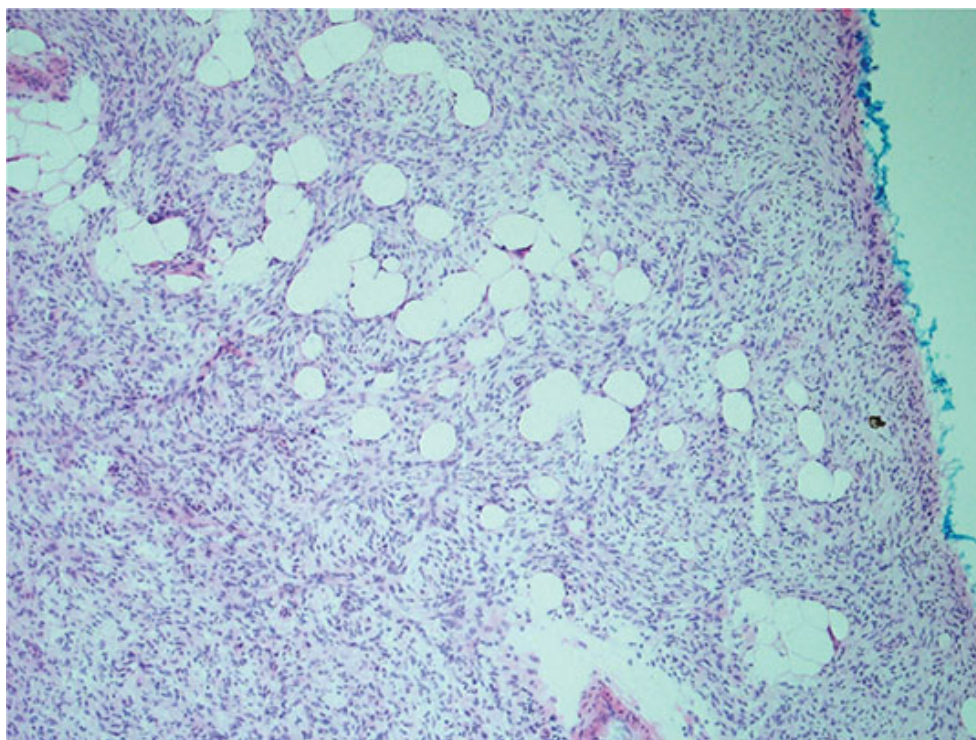


Figure 32-28. Dermatofibrosarcoma protuberans. At higher-power magnification, the tumor is comprised of fascicles of bland, monomorphous spindle-shaped cells arranged in a storiform pattern. Mitotic figures are rare.

Atypical fibroxanthoma

Atypical fibroxanthoma (AFX), also referred to as undifferentiated pleomorphic sarcoma, a term encompassing both AFX and malignant fibrous histiocytoma, is another malignant fibrohistiocytic mesenchymal soft tissue tumor that can occasionally be mistaken for a spindle-cell SCC. The tumor is densely cellular and is comprised of sheets of large, pleomorphic, atypical-appearing spindle-shaped cells haphazardly arranged in a storiform pattern (Figs. 32-29 and 32-30).

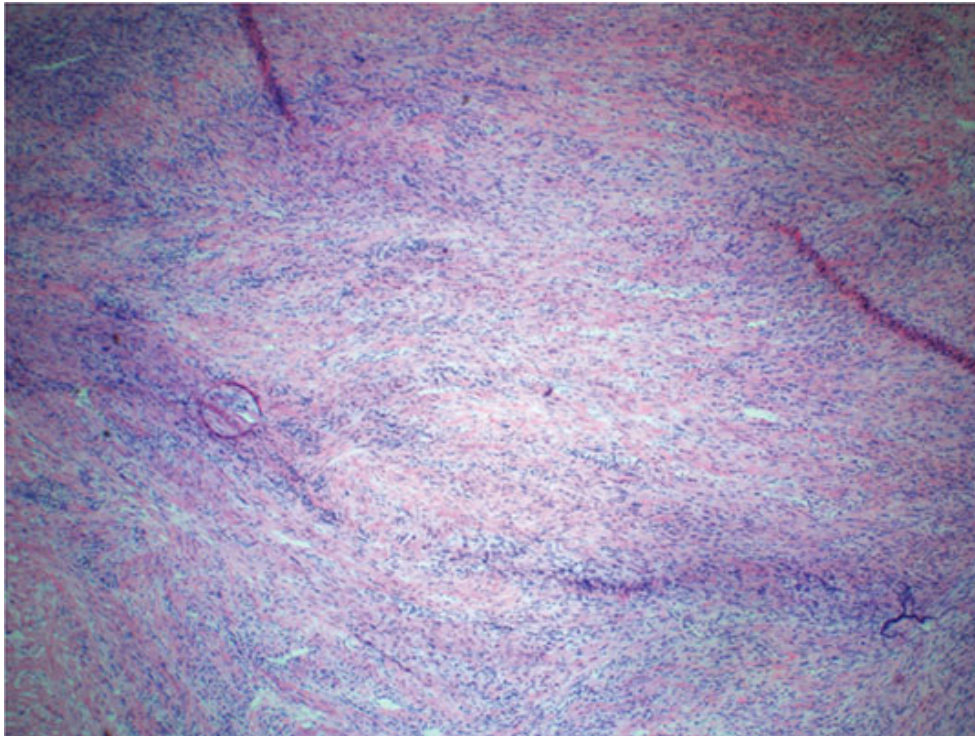


Figure 32-29. Atypical fibroxanthoma. At low-power magnification, the tumor is nonencapsulated, densely cellular, and comprised of sheets of large, pleomorphic, atypical-appearing spindle-shaped cells arranged in a storiform or random pattern.

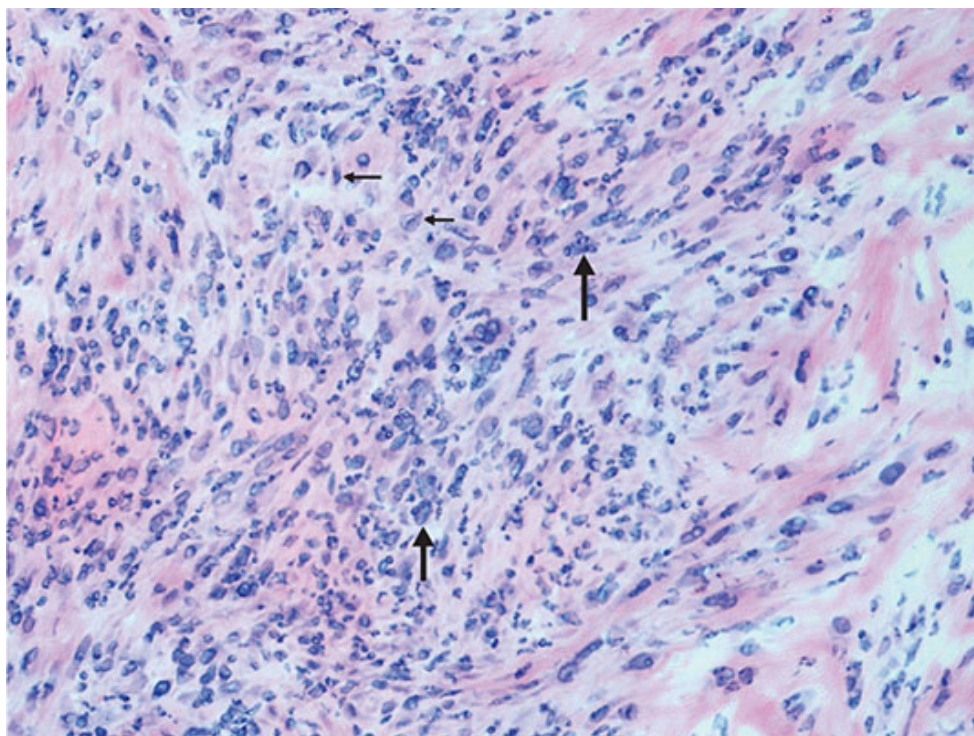


Figure 32-30. Atypical fibroxanthoma. Higher-power magnification demonstrates neoplastic cells that have hyperchromatic, irregular nuclei with varying amounts of bland eosinophilic cytoplasm. Bizarre multinucleated giant cells are often present (*thick black arrows*), as are mitotic figures (*thin black arrows*), including atypical mitoses.

The neoplastic cells have hyperchromatic, irregular nuclei with varying amounts of bland eosinophilic cytoplasm. Bizarre multinucleated giant cells are often present, as are mitotic figures, including atypical mitoses. The tumor is nonencapsulated, starting beneath the epidermis, extending into the reticular dermis and sometimes subcutaneous fat, and has indistinct, infiltrative borders. A Grenz zone is often present, and the overlying epidermis is often atrophied or ulcerated. Of note, solar elastosis is almost always seen in the dermis adjacent to the tumor. AFX stains positively for CD10 (helping to differentiate between that and DFSP), vimentin, and procollagen, and may be positive for CD34 as well.

Sebaceous carcinoma

Sebaceous carcinomas are malignant tumors of sebaceous glands. The neoplastic cells display a variable degree of sebocyte differentiation, and are often markedly pleomorphic, with hyperchromatic, irregular-appearing

nuclei (Figs. 32-31 and 32-32). The tumor aggregates are often comprised of a haphazard mixture of immature nonvacuolated and mature vacuolated neoplastic sebocytes. The aggregates vary in size and shape, and numerous abnormal mitoses are often seen in individual tumor cells. Both solitary and en masse necrosis of neoplastic sebocytes is present as well. The tumor is asymmetric, poorly circumscribed, and has infiltrative borders that may be located superficially or deep extending into the subcutaneous fat. In addition, tumor aggregates may be discontinuous and multicentric. Importantly, the diagnosis of a sebaceous carcinoma, whether solitary or multiple, should raise the concern for Muir–Torre syndrome, and appropriate workup should ensue for germline mutations in mismatch repair genes including MSH2, MLH1, and MSH6.

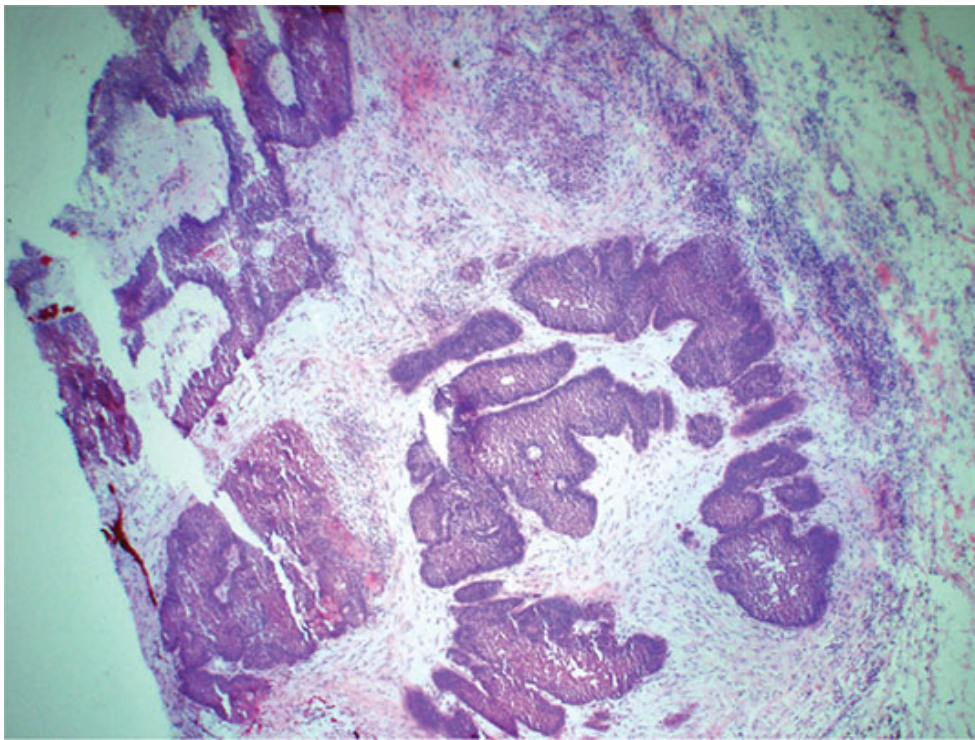


Figure 32-31. Sebaceous carcinoma. At low-power magnification, the tumor aggregates are multicentric, asymmetric, and poorly circumscribed, extending into the subcutaneous fat, showing areas of necrosis.

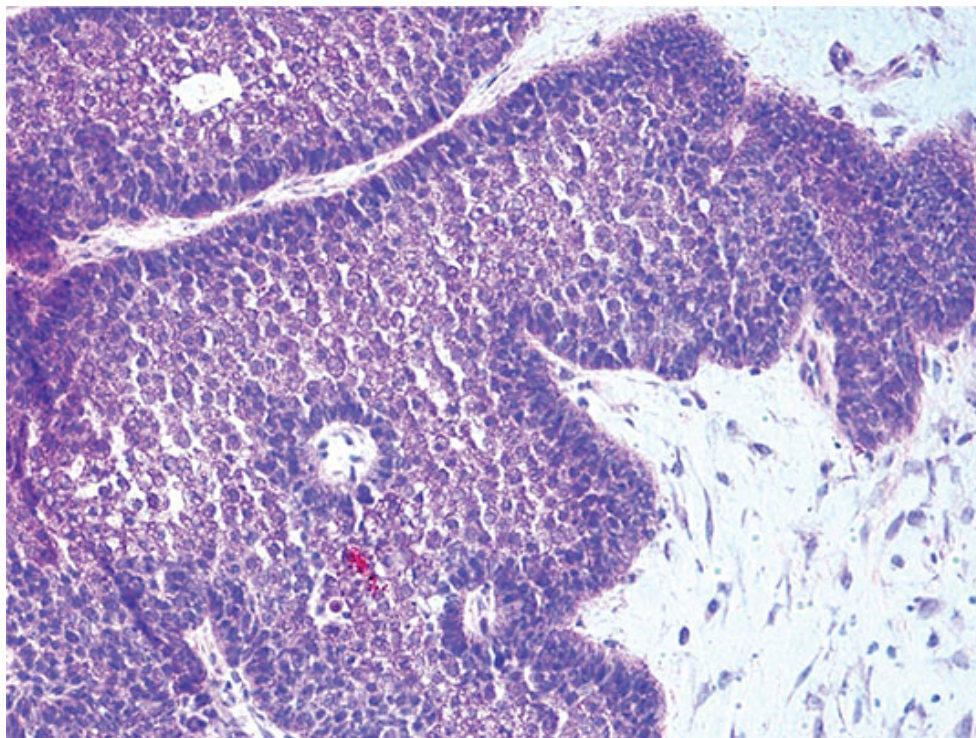


Figure 32-32. Sebaceous carcinoma. At higher-power magnification, the neoplastic tumor cells display a variable to poor degree of sebocyte differentiation and are often markedly pleomorphic, with hyperchromatic, irregular-appearing nuclei. The aggregates of malignant cells are comprised of a haphazard mixture of immature nonvacuolated and mature vacuolated neoplastic sebocytes.

CONCLUSIONS

A thorough appreciation of histopathology is a prerequisite for performing Mohs surgery. While Mohs surgeons typically see patients with pre-existing pathology records, given the potential for collision tumors, the small sampling associated with minute shave biopsy specimens, and the potential for wrong-site surgery, it is critical to always rethink and reassess even ostensibly known diagnoses. Utilizing high-quality pathology sections coupled with an experienced and nuanced eye, Mohs surgery has the ability to provide the highest cure rate for nonmelanoma skin cancer while preserving maximal healthy tissue.

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CHAPTER 33 Laboratory Techniques for Mohs Micrographic Surgery

Jonathan Kantor



SUMMARY

- Laboratory techniques dictate the quality of slides available for interpretation during MMS, and are therefore a critical step in ensuring high-quality patient care.

- While the technologist is responsible for creating the slides that are read by the Mohs surgeon, given the high stakes, the ultimate responsibility for ensuring high-quality interpretable slides rest with the Mohs surgeon him- or herself.

Beginner Pearls



- Ideally, the MMS laboratory should have two cryostats so that in the event of failure, patients are not overly inconvenienced.
- Several options are available for embedding tissue, including the heat-sink method, the glass-slide method, and the cryomold technique.

Expert Tips



- Tissue freezing medium adheres better to dermis than to epidermis, so deep nicks or hatch marks help not only with orientation, but with tissue adherence to the slide as well.
- Thin sections may be challenging to process, as they have a tendency to crumble or fall out of the embedding medium or rapidly flash-freeze prior to unrolling. Several approaches, including scoring with a warm scalpel blade and using cyanoacrylate glue, may be helpful.

Don't Forget!



- Orienting relaxing incisions medial to the epidermal edge on a 20- to 45-degree angle may help allow the tissue to gently flatten out.
- Charged, or so-called plus slides, may be helpful in encouraging tissue to adhere well to the slide.

Pitfalls and Cautions



- Slides should be wiped carefully; technicians who have trained with permanent section preparation may not be familiar with the rapidity with which Mohs surgeons begin to read slides.
- Formation of an opaque film over the slide may result from the use of incompatible clearing agents and coverslipping media.
- Most staining issues can be addressed by using compatible chemicals and by sufficiently blotting the slides and rack between reagents in order to avoid dilution and neutralization.

Patient Education Points



- Explaining to patients that all MMS laboratories are federally regulated may help bolster their confidence in the quality of an office-based laboratory.
- The laboratory area should be centrally located for ease of access and clearly marked so that patients do not inadvertently attempt entry.

Billing Pearls



- When billing Medicare for MMS, the laboratory's CLIA number must be attached to all claims.

CHAPTER 33 Laboratory Techniques for Mohs Micrographic Surgery

INTRODUCTION

High-quality histologic sections are the foundation on which Mohs micrographic surgery (MMS) is built. Indeed, the goal of complete margin control cannot possibly be attained if the Mohs surgeon is unable to effectively assess complete margins by reviewing crisp, clear, and complete histologic sections.

While much attention has historically been paid to MMS slide interpretation—and particularly post-MMS reconstruction—an appreciation of laboratory techniques for MMS slide preparation is of vital importance. In general, the technologist is responsible for creating the slides that are read by the Mohs surgeon, but given the high stakes, the ultimate responsibility for ensuring high-quality interpretable slides rest with the Mohs surgeon him- or herself. Therefore, understanding the fundamental laboratory techniques, as well as having a grasp of some of the most common troubleshooting scenarios, is of great value.

ACCREDITATION

Laboratory accreditation in the United States requires a CLIA certificate of compliance. MMS laboratories are considered high-complexity laboratories; as such, the laboratory director (usually the Mohs surgeon) must be a physician and meet certain requirements for experience, expertise, and training. Dermatology residency training, with its emphasis on dermatopathology, is a requisite for becoming a laboratory director. Anatomic pathologists may similarly be laboratory directors for high-complexity testing.

State law regarding laboratory licensure varies considerably, though minimum federal CLIA requirements must always be met. The MMS technician must similarly have a minimum level of training if they are to gross tissue, including an Associate's in Science degree or equivalent coursework and training. MMS laboratories that rely on the Mohs surgeon to perform all grossing do not require a technician to meet these criteria, since their work falls under a laboratory assistant category, though an experienced Mohs-trained histotechnician or histotechnologist is always desirable. Still, considerable variation in training and background for laboratory personnel persists.^{1,2}

When billing Medicare for MMS, the laboratory's CLIA number must be attached to all claims. Therefore, Mohs surgeons should bill under their own laboratories when performing MMS.

Several other options are available for accreditation, including the College of American Pathologists (CAP), which has additional requirements (and costs) beyond CLIA. Given the increased costs associated with this additional accreditation, it is infrequently pursued for MMS-only laboratories. Outside of the United States, laboratory accreditation approaches vary widely.^{3,4}

EQUIPMENT

The MMS laboratory includes several key pieces of equipment, foremost among them the cryostat. Essentially a microtome set inside of a freezer, modern cryostats permit the technologist to freeze tissue and section it appropriately for mounting on the slide. A wide array of cryostats are available from several manufacturers; given the substantial cost of repair, investigating purchase or lease options as well as included maintenance or

warranty plans is highly advisable. Ideally, the MMS laboratory should have two cryostats so that in the event of failure, patients are not overly inconvenienced. If this is not possible, an arrangement with another nearby laboratory is of great value, and may be required in some areas for accreditation. Regular maintenance is required for such precision equipment, and most cryostats are serviced at least annually.

Many MMS-specific laboratories rely on hand staining, though automated linear strainers may be used as well. The increased efficiency of automated strainers should be weighed against their cost and potential for breakdown. Manual staining equipment should always be available as a backup.

Staining is generally performed inside a ventilation hood. Two broad categories of hoods are available, those that are vented to the outside and those that are not (ductless). Ductless hoods may be more convenient when adding an MMS laboratory into an existing space, though this should be weighed against the long-term increased cost associated with frequent filter maintenance, replacement, and disposal. Given the risk of exposure to toxic chemicals, including formaldehyde and volatile organic compounds, the use of a ventilation hood is highly advisable.⁵

The laboratory environment is important for optimizing slide quality. Maintaining a low humidity and temperature permits efficient cryostat operation and minimizes the need for frequent defrosting. This is a particular challenge in geographic locations prone to high humidity.⁶

Safety equipment in the laboratory includes an eye wash station, gloves, and gowns. Emergency spill protocols should be in place as well; cat litter is an inexpensive alternative to specialized chemical spill response kits.

PREPARING FOR MOUNTING AND EMBEDDING

Prior to mounting and embedding the specimen, several key steps may help ensure that high-quality slides will result. Most importantly, tissue orientation must always be preserved. Some Mohs surgeons prefer to mark, nick, and orient the specimen while in the room with the patient; this approach minimizes the risk of incorrectly oriented specimens, and for experienced Mohs surgeons takes only a few seconds for most cases.

Alternatively, the technician may be delegated the task of tissue division, nicking, relaxing, and marking. In such cases, particularly careful attention should be paid to maintaining orientation as the involvement of an additional person introduces the possibility of error. Various nick and marking protocols are available, and are subject to individual surgeon preference.^{7,8}

Traditional MMS sections are taken at a bevel to permit flattening and ensuing margin interpretation. Some authors have suggested that only a minimal bevel is needed.⁹ There are, however, other options available to the Mohs surgeon, and some have advocated removing tissue using perpendicular incisions and relying on full-thickness relaxing incisions to permit the tissue to lay flat.^{10,11} One advantage of this approach is that it may lead to smaller ultimate defects, though it should be used with caution when removing thicker sections that may resist flattening even with significant radial relaxing incisions. Another advantage is that this approach may be less likely to transect the deep margin of tumor. Certain anatomic locations, such as the eyelids, can have sections removed perpendicular to the skin without compromising the ability to evaluate the margins.

Dehydrating the specimen reduces ice crystal formation and ultimately leads to higher-quality sections. While some have raised concerns that compressing the specimen could artificially shift tumor location, the net result of tissue dehydration by blotting or gently squeezing in gauze is higher-quality sections, and the theoretical concern regarding tumor shift has not been demonstrated.¹⁰

Several options are available for specimen processing. Until several decades ago, MMS specimens were typically bisected, though more recently processing MMS stages as a single specimen has come into vogue.^{12–14} This approach has the advantage of both minimizing the risk of orientation error while also being faster and more efficient for the technician. Moreover, laboratory errors may stem in large part from specimen division, and therefore processing sections in their entirety confers an additional significant quality advantage.¹⁵

When necessary, MMS specimens may be bisected. Thicker sections may benefit from relaxing incisions. Multiple relaxing incisions are sometimes needed, though increasing the depth of the relaxing incision may be more helpful than adding an additional shallow score. Several approaches to relaxing incisions are possible; the goal is to permit adequate tissue

flattening while avoiding full-thickness cuts that may result in false-positive or false-negative results when evaluating the deep margin.⁷ Orienting relaxing incisions medial to the epidermal edge on a 20- to 45-degree angle may help allow the tissue to gently flatten out.¹⁶

Some Mohs surgeons and technicians prefer to squash and freeze the specimen in place, arguing that this obviates the risk of relaxing incisions extending too deeply. While true, tissue that is under significant tension is more likely to curl back in when cutting, and may be more likely to be pushed out of the freeze medium en bloc (chunking out). Conversely, some surgeons place multiple deep and dramatic nicks in the tissue to permit it to lay flat (the blooming onion approach).¹⁷ This too may result in issues with deep margin interpretation.

When processing the specimen, note that tissue freezing medium (TFM) adheres better to dermis than to epidermis. Therefore, utilizing deep nicks or hatch marks helps not only with orientation, but with tissue adherence to the slide as well. When cutting tissue, orient the specimen so that the edge with the deepest nick (often 12 o'clock) is the first to be cut by the blade.

Given the better adherence of freezing medium to dermis than epidermis, thin sections may be challenging to process, as they have a tendency to crumble or fall out of the embedding medium and, if the edges are curled, rapidly flash-freeze prior to unrolling. Several approaches, including scoring with a warm scalpel blade and using cyanoacrylate glue, have been proposed as workarounds in these situations.^{18,19}

Fat and cartilage require special considerations. Fat freezes at a lower temperature than skin, and therefore, if a fatty specimen is processed in a traditional fashion it often does not have sufficient time to freeze prior to sectioning.²⁰ Flash freezing in an isopentane histobath, or using a Miami Special device in a liquid nitrogen bath, may be helpful in such cases.²¹ Alternatively, use of liquid nitrogen sprayed, poured, or painted over the section may also help drop the temperature of the fatty section, though the latter approach may only freeze the fat inconsistently, leading to less than optimal sections. Delaying sectioning to permit the entire specimen to drop to a lower temperature is another option, though this is generally not favored. Finally, cutting thicker sections is another option when fat cutting remains a challenge, though this approach yields sections that may be more difficult to interpret.

Cartilage may shatter when cut at too low a temperature, and its native inelasticity, which makes it so valuable during surgical reconstruction, means that encouraging it to lay flat for an ideal section may be a challenge. Combining deep relaxing incisions centrally and peripherally with a slightly higher cutting temperature may yield the best results. Cartilage also has a tendency to wash off the slide during staining, and therefore a gentle touch is of great value.

Finally, wedge excisions may be particularly challenging to process, given the three-dimensional nature of the margins that need to be examined. Classically, the lateral margins are spread, separated, and processed in such cases, or the wedge is bisected and spread apart in a butterfly fashion. Processing wedges in each plane in a serial fashion has also been described.²²

EMBEDDING

Several options are available for embedding tissue. Commonly used approaches include the heat-sink method, the glass-slide method, and the cryomold technique. Myriad other specialized options are available including the Cryoembedder, Miami Special, Cryocup, and CryoHist, though a litany of other approaches have been advocated in the past as well.^{10,11,23–26}

Heat-sink method

The heat-sink method is one of the simplest methods of embedding. The inked, nicked, and relaxed specimen is placed on a handheld heat sink, and the epidermal edges are flattened in place using forceps (Fig. 33-1). This approach may also be used directly with the freeze bar in a cryostat, though using a handheld heat sink is ergonomically more straightforward. The flattening is time sensitive, as fresh tissue adheres well to the heat sink where it freezes immediately, but frozen tissue tends to rest in place with minimal adherence. If necessary, optimal cutting temperature (OCT)-compound rescue may be used to help adhere the edges in place. OCT is placed on a room-temperature chuck, which is then placed inside the cryostat and allowed to freeze (Fig. 33-2).



Figure 33-1. The heat-sink method is one of the simplest methods of embedding. The inked, nicked, and relaxed specimen is placed on a handheld heat sink, and the epidermal edges are flattened in place using forceps.



Figure 33-2. OCT is placed on a room-temperature chuck, which is then placed inside the cryostat and allowed to freeze.

OCT is also placed over the adhered specimen on the heat sink (Fig. 33-3), which is placed specimen-up on the cryostat freeze bar. Once the OCT begins to set (Fig. 33-4), the chuck and heat-sink OCT are gently pressed together and allowed to freeze in place (Fig. 33-5). Once fully set, the heat sink is twisted off the chuck (Fig. 33-6), additional OCT is added, and the specimen is ready for sectioning (Fig. 33-7). The advantage of starting with a room-temperature chuck is that it permits the OCT to enter the crevices and adhere more effectively.

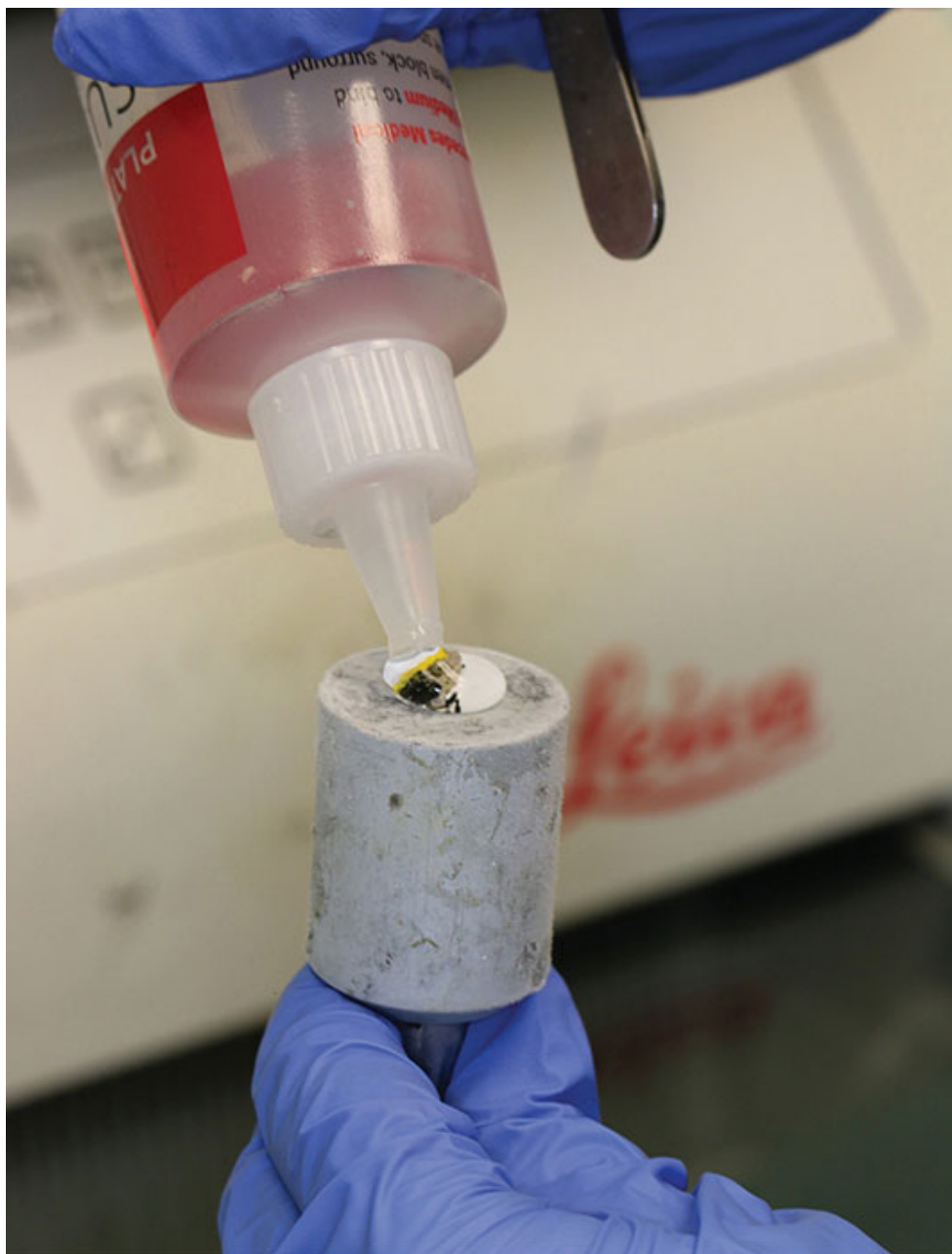


Figure 33-3. OCT is also placed over the adhered specimen on the heat sink.

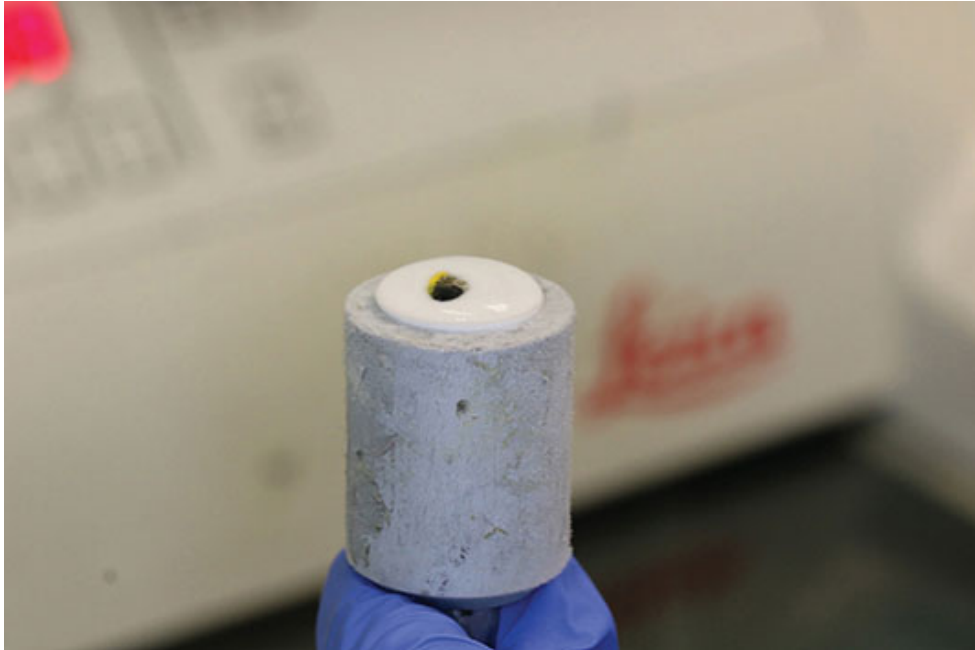


Figure 33-4. The OCT begins to opacify and set.



Figure 33-5. The chuck and heat-sink OCT are gently pressed together and allowed to freeze in place.

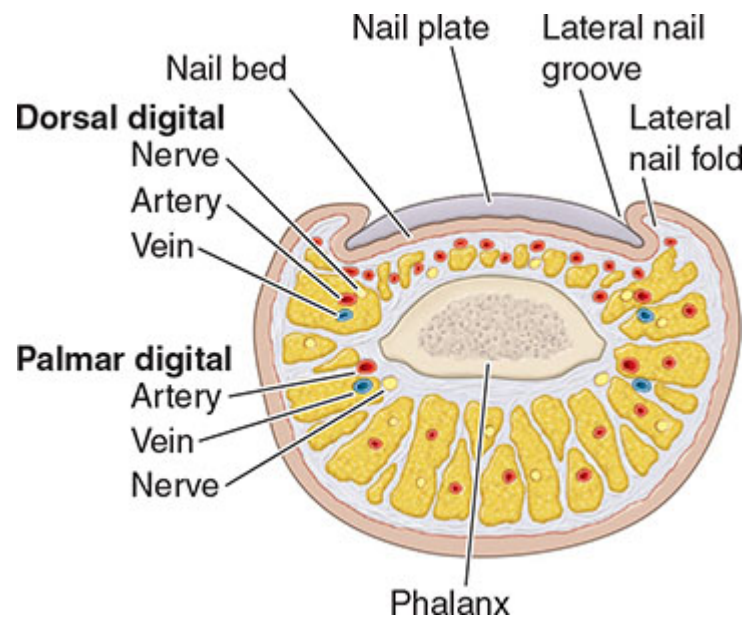


Figure 33-6. Once fully set, the heat sink is twisted off the chuck.



Figure 33-7. The specimen is then ready for sectioning. Note that the deep 12 o'clock nick is oriented downwards.

Glass-slide method



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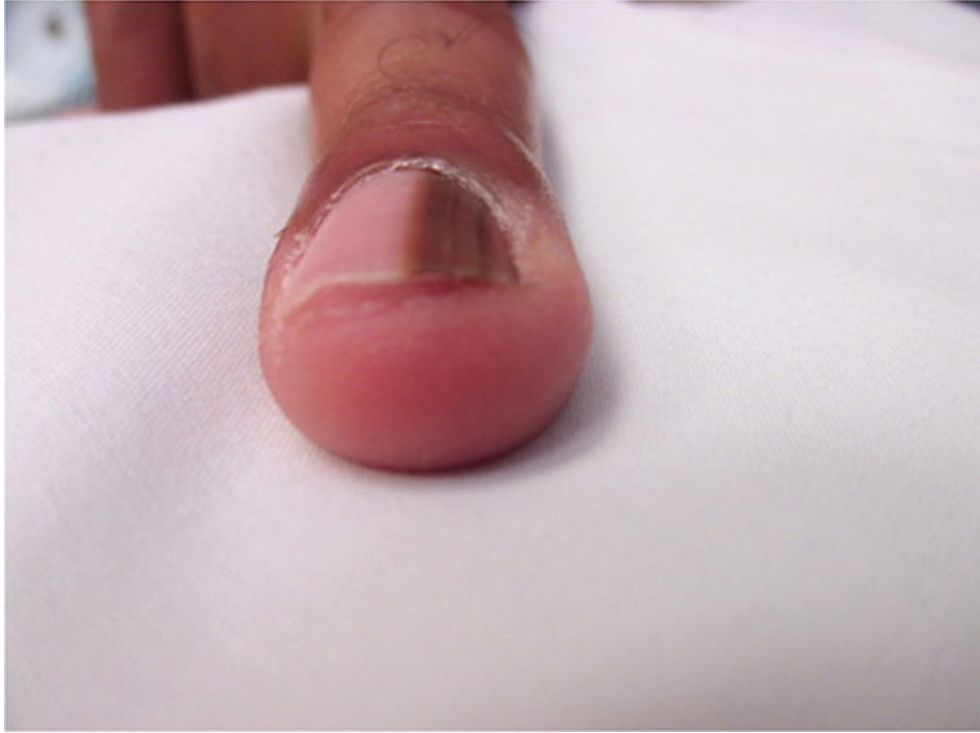
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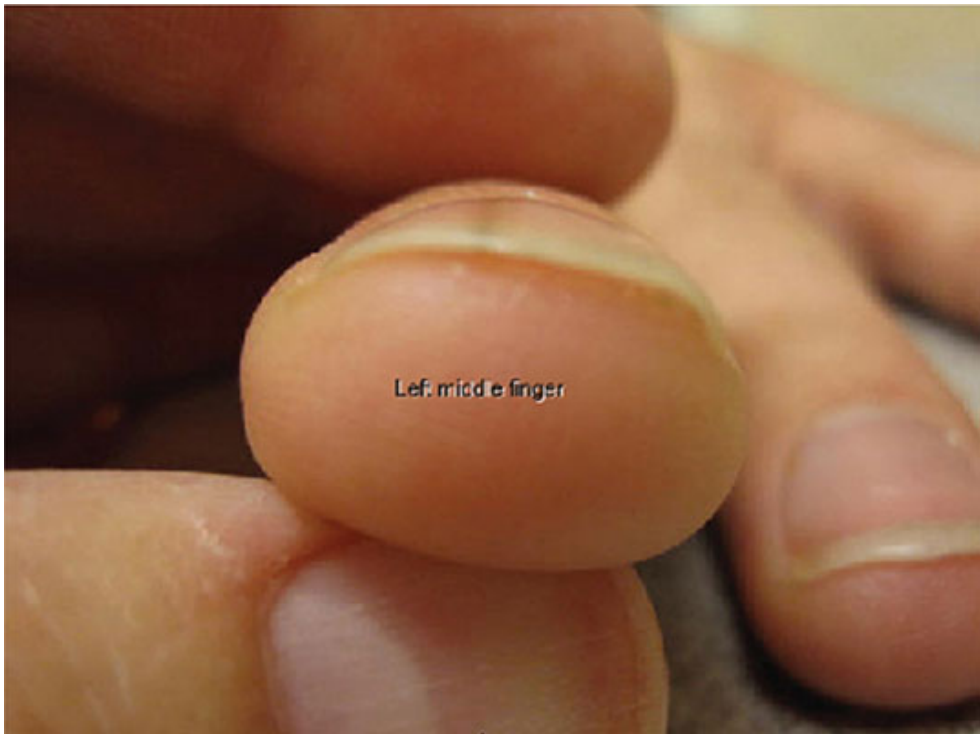
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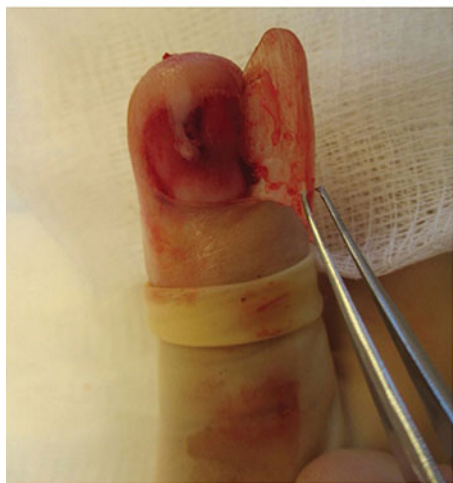
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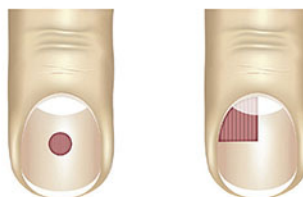
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FR IE QG BQ EFOQNR QR MM SRUPDORQ [SHR MM IR IS KM QLO
PDM [DH) LJ % SRKUR R RVV MM VDS G R RUMR Q ZKHU
VH SDM RHQKO GVFK-G UR P V EGI V DNG SXDMA IR R G DHEU
) LJ '

5HS OQJ MM SUNDOD D BNG QLOSDM DAU XJHV EG RV
S RAV/SUNY HSLQ RH QLOSDM VY M D DERLOIF GHULQJ SRURV
KDOQJ QG BAVQJ MM FRH GQDM QG HOLQJ VVAVH RH QLO
VR B EVFXUG RMMQLOXWZLV Q QE REBEOQR Q R
DFFR ISOK M/ LVW BOD PP IRDMR JK MM QLOSDM XQJ Q
E Q H H W SDMA XAVH QGHOMR JK MM RVVAVH QG KMQ SV MM
QHGHOMR JK MM SHG QG RQ RHU DH RIR BQ QXQHV Q ZKFK
VH QLOSDM EQQR V HS DNG EDMH VV R/R VGR SLK R WPAWE H
VE RVNG RI URFUR RR SLOGR URFUR ERLOIF N DDMR Q

0 DM [FVAP \

3DUNDODM [FVAP R V DXHXO SRUG DH R UAY EH R UFXUHQV
R QFR BSRV %FDXH R MM QALS D EVH HQ MM QLOSDM KVRW
VAVH R MM GILV QG KMSRVAVY HXQNR QR MM SDM RV
PDM [FVAP R V DSRUG DH R MM DMVR WZKHQ MM GVHG QG SQW/
S HPDQHMPR YOH J QLEHV R RQKR US R V

0 DM [FVAP R EQ E SHR RHG XJLFO R BPLFO BULFO
PDM [FVAP R V MKQFO FRH KQDQJQJ RH SLQXO QG RHVAV
FR QPLQ MQ RPLFOGVAVR QI, GUQJ XJLFO PDM [FVAP R Q
UPQQMR PDM [V BWEKQG SHEH R QLOSDM ZLOHUR Z D QLO
VS EXH

&KPIEDOGVAKNR QR MA FDMZ ZLV SHQR O R/GPL KGRJ[G H
 RUMKOR R EHF DLG 7&\$ V DIPSIO IHFLQW OG HIDE IO
 S RFG OH ZLV B ZU EFUHQH DAV MQ VULFDO QMY ENR Q[±] \$VUJ
 VH GILWZ QVWVHG QG [MQXLQDAG ZX MA XH R DR/MQT XW D
 VLEN SPUNY HQHUR SVRIOP MO V IS SHG RQWMSUHR QKXP \$
 DNUOVIS RQLOSDN V D XHG QG DNUQW IS SHG RVW/FDMZ R I
 RQW VR GPL KGRJ[G HQG &\$ R U RQWV SKQR O) LJ \$
 VLV S R/V GNR QDMHMQ QNUDQ DNR QVLSUHRPHG VQZ VQCH
 UDMHMQ DRR O\$JHDX EON GHMLQ V MQ IS SHG R3V SUBV H
 S DQ V RQPDOHS FLDQ R USHR QG &\$ KAVGNR \MA M/PLQD
 P\HQJHG HQ HQGQV QG VLKQ IR QROG ZX DHVPLQR SHQ R U
 QR QVRG ODM/QOPPDR UDHQV B V SUBV HEUH QFOG V GLO
 VR PLQW R V Q ZUP ZDU BNFQV VR QG EIGHDAG KWR EQ
 ZLOSUMWR US RV HNV DNU MA SPUG OH QG KVMQ IEXMQ
 VR QG EHQO EPR YGH



) LJXUH &KPIEDOPDMZ HFVP\

6XUJLFDO\$ SSURDFKHV

Nail Bed

: KHQ MM R NH R SVRRUJ ENBG RSQKLFDOHDPLONR QCGQV V
QRNG RWEQMM QLOEGH QLOEGH E S W QGHDAG I Q QFLMR QV
QHFWDU QDQ WMR QMM R QVAGQDDLV R MM GJLWVLPWMM UN R I
VFDUQJ DG SVRSUBLY HQLOGIRPLWV QEOGQ S QWQLO
3XQFK %R S R WH 1DQ%G \$ R/ PP SQK ERLS VR MM EGH
ZLOIKDOYDLVR QD QANR QZWK YUH WDH UN R WDUQJ) LJ
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) LJXUH \$ %& 1 DCEGSXQK EFSX

\$ IR IP R CQG FDN R QR UNV SRUG NH V MA GIEHQND GDIQR W R I
 VAE QIXDO KS HHDR W MWFD HXOMR P QLO SRMDLV R UKHQ SDQV
 6T XPR X FODIULQR ID R MA EGVLD R IP R CQG FDN R Q KH SQK
 VR R IDQHUNG RVME RIQLQ DZLVNQ FRUV Q \$ QUR ZVS SGHAXR L
 VFK ID UV FLWR UL XHG RVQS KAVEI R MA S FLPHQ RI MA
 S HR WP FLV EQ E HEVMEKHY B EQHUNQ MA FLWR US V
 S ES EGEXOU R/KW/QLOEG XUDH G FQZV SURWP ZV MA FUY DUH
 IDLQJ S ZUG VMAQ R SEI MA S VQG XULQ MA R SHFLWR US VOR Q
 WH ENI R MA ERLS VS FLPHQ KH ERLS VS FLPHQ MQ EQ E QS SGH
 IUH UR PMA SUR WP I, S RLVIO BY MAMA S FLPHQ ZV MA FLWR V
 DV XLQJ R IUS VFA EXK MA GOFDM S FLPHQ SZ DV IFHN MAMA
 S QK RVR IDUH R WXH SUR UR QFUGQ

1 DQ%G QFLVR Q 7KH QLOEGVLCFLHG RVBR Y BQLOEGIXVR U
 H J TVXPR X FODIULQR ID R R R SSOR ID R WHFK DGHS XPR U
 H J Q FV XPR UR MA QLOEG RVE QIXDO IHR VR W \$AU DSUNDOR
 D DNDOSDM Y QLR QKW DHD R MA QY RYB QDEGVLCO IHS RY
 \$Q QFLVR QR MA EGHKR G EHQG QDQ MA B QVAGQO DLV R MA
 GJLVV/LQVMA UN R FDUUQ DG SVR SUDY HQLOGIRPLW

7KH QDSVDOIFLVR QV EUHG XN D ECHQG KR G EQ
 ZLG HMQ P R/LQVMA UNV R R/QR/V) LJ \$±' KH QLO
 E B GKHV VR QD R/KWE R QDQ QG VLMUHRH HONV B
 LPPR EDL SIDS SRUPDN R QR WXH IG BV HT XUV ZLG HQG UPLQQ R I
 WH DNDIG BV R MA ZR QG XN MA EDG H BG UPLQQ VR G EBUHG
 R WDMA BY BR SUR WP NPPLQ MA E RIQR UDJHU GIHFV
 Q QVAGQO HODMLQ QFLVR Q SUDOR R/KW/DNDIG BI R MA QDS M
 DAR EDAG XN DNDXG UPLQQ WH RANQ HT XHG LK MQR QBUR V
 WH WUXV V Q VFR PHQG B VMA UDLOH QLOEG B MUR I BVR I
 WH GIHFV E HVA/HOE VFR QD QANR Q XULQ V SUR PHG

ZLW EREBIOXUH RH SDN V DZDV SWERN Q SDH VR JK
VR PH DNDOMPLOQ FA E HFWDU OG HXUG RVMDNDQLOV
IRGV



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)LXUH ([FMRQR QDOHG \$ 2 Q KRFXYVR GMDQDOHG % 1 DCSMUHPRYDOR
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DVUH FMRQR RQ KRFXYV

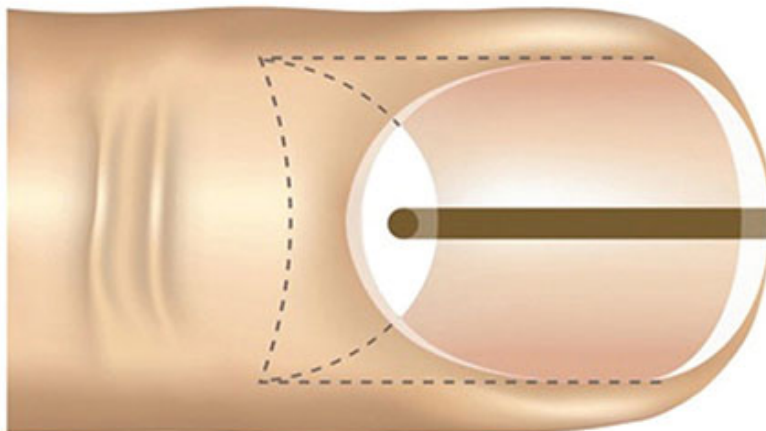
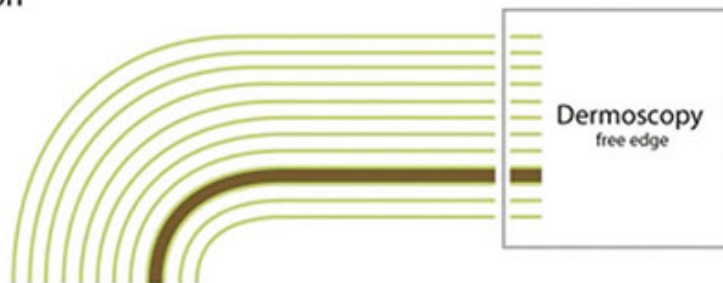
Matrix

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LV QGHNG KH FLO QGHNR QR UFDNU ERLS V B QNGQO
PHQR QKD RV VR OG ESURPHG VDO HFLVR QD ERLS VR QMUH
FR IS KM HPLQNR QR MM SJHQNG HOR QE MM SVRDLW & IS KM
YXDOJ DNR QR MM FNU DHD V FQGV VU RV V SUHFO DKHY B DV
D SRUPDOSUNDOQLO DVLR QR IS KNG DV DEFQNR QR MM SRUPDO
IRGV

,Q R PH EVHV KW FNU V QLVG RVHDK DYE FNUFDOPR U
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R MM GILVR/PLWS RVSUNY HQLOGIRPLV VS FDO \$ KMQO

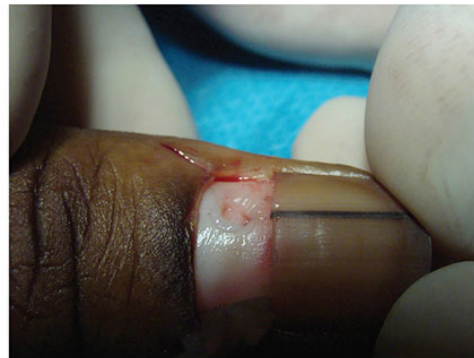
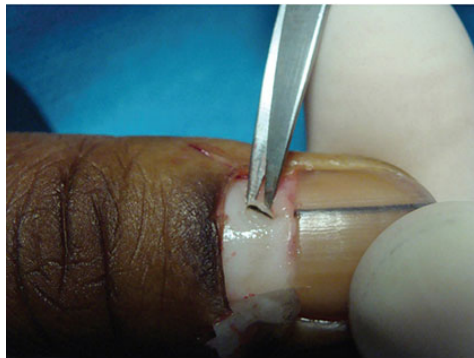
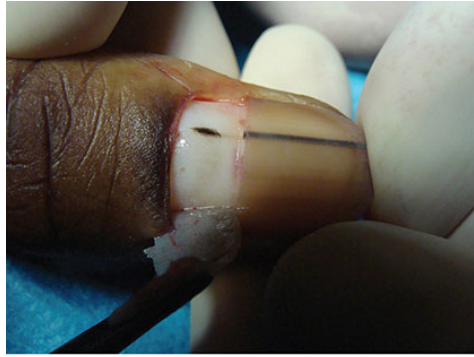
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 Q EOHG EGUPR R R S R MATH PDJLQ R MA QLOSDM) LJ
 \$V MA GNDQLO PDJL JY M UH R/KM/XG UXUDH R MA QLOSDM
 ER SLW Q MW DHD IDY HDB Z UN R PDJLQ VFXH MA SRUPDO QLO
 PDJL JY M UH R/KM/XG SUHUR MA QLOSDM ER SLW Q MW DHD DH
 PRH DHD R/QG FH XUDH GWR S KR QLO PDJLQ

Nail plate,
longitudinal section



) LJXH ' IDJUP R RUJQR SJPHQW/KHRUJQR PHOQO FKDFDQEHOFDQHGE
 GHUPRFRS R WHIHPDJQR WHQLOSDM

3XQFK %R S 7KV SRUG DH V DYUH VPSIDQ DM R SRVQ U
 SJPHQNG HOR QR MA GNDQLO EW MQ P Q GEHNU \$WUD
 S R [PDQLOD YWR QHS RQ MA QNH PDJL KW SJPHQNG IFXH V
 UPR YH ZK DSQK MKQT X G RQZ/KM/SUR WAP QG DK MNG QLM
 VPH DKR QV GVUE B RI UQOEG SFX ERLSW) LJ \$± ' RH
 SDM V HS OHG QG HXUG RMM/DNDQLO R G) LJ (



)LXUH \$ 3URIPDDYXORQH SRHVPDM DQGSJPHONGPDXOI % 3XQKIQ VHPDFOI
 & +DYHMZQ VHVSHPHQZ LKVFVRV ' ' HFMQVHPDM OIWRUMFRQDU LQMQRKHDOQ
 (1DCSDMU-SOF-GDOGVMUHGVRVHOMJODDORG

7D QHQM D KD Y PIR S ZDJQND WY HERLS VR MM FDM I V D
H WPHD XHXOMAKQT X DG VLZG G HDUG G EPD QLOXJHR Q D
VH SHUHG PIR GR UPR YOR ZLG H P PFXOU SJETHNG
DMR Q R MM FDM I QEOGQ MM SRUPDO FDM I 7LV MAKQT X ZLH
WFKQFD GHDGQ SRUGLH RVNDGQ UHXOV Q VLOG DG V QG
DOR ZV D THAM GILOR W Q D D EHV W FLQ GZJE EN V D EFXUHQH R
VH SJETHQMR QQ E RVX R EHV 5-PR YOR DMQ D HUR FDM I
PD HXOMQ DMQHU QLO QG V HUH D OG GVR S K

\$ IAU SUND OLO Y XLR QW [IS RMM FDM] DMDR Z QFLVR QV
 FDWHG RMR OG KMSJEHQAG R Q ZK FMD FDJLQV RH VDS BV
 VHQ KOG RQUR QD OG KVMER QV LPR YGUR PMA GHE QPHV XIQ
 D JQOH VZ LQ FRW Q RH S FLPQ VR OG FQV HMFHUMQ PP RH
 VS FLPQ V SDHG FSSUN RUHQAG FDQOMP SDM Q DEXHMM R UMM
 S DRDLWV) LJ RH Y XHG DQV LS DFG QG HXHG RMMW
 DMDOR G



) LXUH 1 DOS-FIP HQVXP LMRQ) LMSDS UNH SVWHVS-FIP HQV LMDQGIPP HXGLO
 I RUP DQGUQ I L DMRQ ' HSENGLDVS-FIP HQV XQDQWUP WQHQWOKDYHERSX R D SJPHQAG
 QMRQR VHQDOP DM VQVZ DVFRQLP HGREHDE QJQMQRQDQHXV

/ D MMD OR QVXGQD Q FLMR Q Q %R F(FLMR Q)R UMDOD B BAG
 OR QVXGQD OFDQ QKLD R BMM MP RVH J TVPR X FQD EULQR PD Q
 VMM DMDOR QVXGQD FLMR Q DH QGHDAG 7KH SVMQMPXWE H
 LQR PHG KMMW VS HR ERLS VZQ QUR Z MM QLO SURDQHQ GHXW
 S DNDIDS XMR QR MM DMDOR QR MM FDM

7KH S FLPQ VR OG FQMFHGG PPQ ZLGKQV RGHWRV YDFGL
 S RAVSUNY HMDDGYHMR Q 7KH QFLVR QEJHQ KOZ D EVH HQ MM
 FAXFH QG KMFHDM R MM GMD QMS KOQHDO RQMQG XQV GMD

VUR JK MA SRUPDOQOR G QEKVQLOSDM QLOEGH QMOMA
 K S R ELP V EPHG \$FR Q QELVR QSUH RPHG QMA DNUOQOR G
 S DDOV MA LUW OG RM/ WDMA IS RMA LQHU GR IPDO KW QELVR C
 VNHV R QONUDO RUY B QHVR QMAMFVQ VE RAX P DNUO Q
 R GUH/HER Y MA DNUO RQR MA FDM) LJ \$ 7LV V
 HS FDOO ES RQVZK-Q ERLS Q MA JHDM/DO RH S FPHQ V MQ
 FDUHXO GPHK-G UR PMA E RIQV LQ VLR V \$MA SRUPDOIS RMA
 E R S VAV FDM PXWE ISHLY B Q SUXOU EUH VR S EDMQ R/
 DY FGLVQ MA VLR V/VR RR R OG RIHVR VQO MA S FPHQ RH
 G IHFW HDS SRUPDAG X R R UR QO FDMH VMAHV Q R GUH/
 UFUDM DNUOQOR G) LJ % RV VS HR IFHVR QOR Z/ MA
 VVG \R MA ZKRQLOIS SUDV SRUPDOQOR G DM QOEG DQ
 SDM OG \S R ELP RH DE FDUV OG QHVR SRRDUMVR S E H
 HS HPHGZLV KQGLQ VFK S FPHQ OG HVR QMP B QVAGQO R
 DOR Z YVDO DNR QR MA DFKVFXH R MA SJPHQNG HOR Q



A

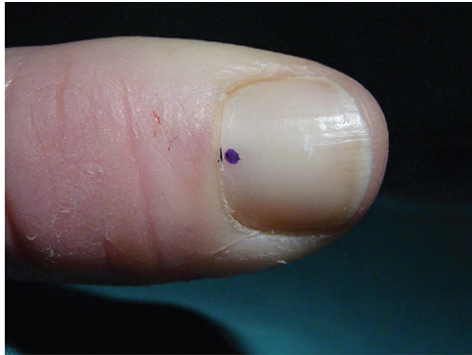


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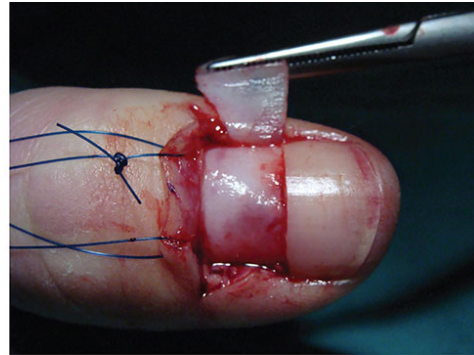
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 Q\ 6 IQFVRQVDFXV/SUR IPDO VEHVXVVRUP RYHVAH DNUOKRQR VHP DM % / DNUO
 QVAGQOERSX VAVQ SHHVO UHSSUR IPDMVHHGJHVR VHH FVRQ

O DM/ (FVR Q GR PUPHV KW SJPHQNG BFXH FA SHVQMD D
 QUR Z B QVAGQO SVK RV FA E HPR YGHVQ DB QVAGQOIDS M
 ZLV RQPDOPULQ/ RH B BV R MA QELVR QDH ZIG B XG UPLQG Q
 UHS SRUPDAG X R U B R E B XAVH RH QOV OG ENDQ
 SDH OG XVHG RMAV DNUOQOR G I MA SRUPDOQO FDM V Q W
 LQ RY B KHV N R GVVR SLK VT KDH V YUH QNH \$RKAU EPR YOD
 R SRVQ MA QH QND IFHVR Q

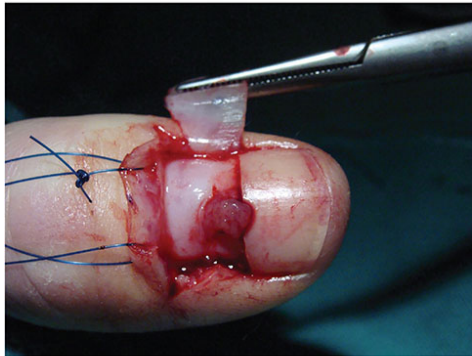
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 JOR XV XPR UXS HLFDO DDOLE B R R D R SHG R IPRG I W
 ,QFLR Q DH EUHG M Q M QY BH R BU Q DU DKR QZK D
 E Q H Q M GNDPDI DZ FLOPHU/ EHQG KMMQWR QR M QLO
 PDNI QG DQEG QXU ZK RU EREBIOXUHYR Q E H
 S HRPBG QHND QG HRPQDOMR Q L $\$ \pm *$



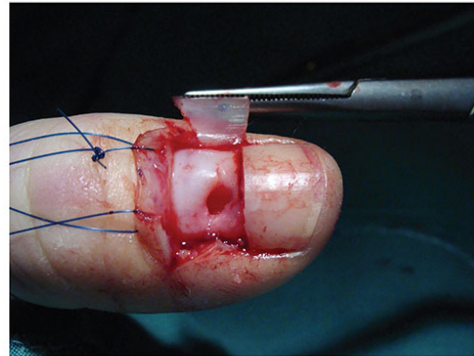
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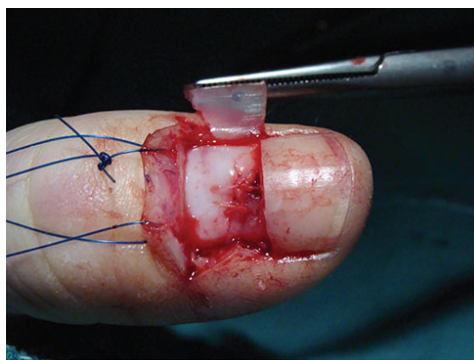
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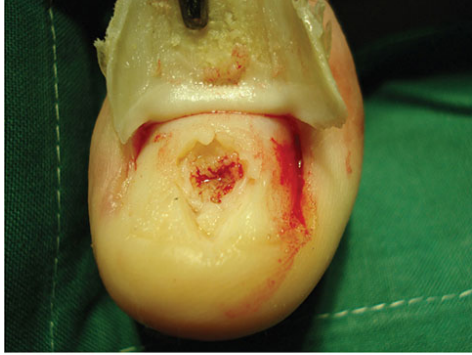


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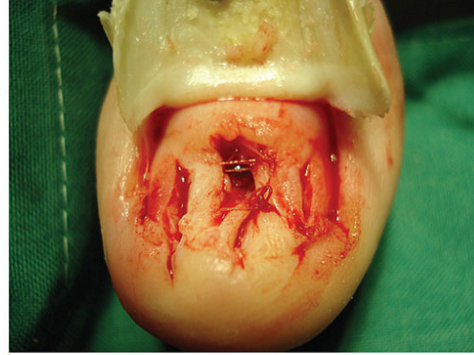
) LXXUH \$ * @PXVMPRUGVMDP DNL 3URYRNGE / RYHVMW % 3UR IP DODYXORQH SRVQI
 PDNL & , QFMRQI VHP DNL DQGH VSDURQI VHP RU ' ' HFWI WUVP RUHP RYDO (
 \$ SSHDQFHDIWUXMUQI VHP DNL) 5HSDHQI VHSOMDQGVFXUQI VRQDORV *
 \$ SSHDQFHDIW PRQVSRVSHUDMHO 1 DOUHURZ IQJ Z LKRWG VWSKI

Flaps

7ZR HQNDOS VIDH XHG QLOVJHU RH LXXM DIR IE QNR QR NR
 VPDDR QVAGQDOELG H DS V VHG RVR M DGIHFWJHUMQ P R Q
 VHQLOEG) L \$± & KLV IS SRUEK @LW MM S RLVQV R I
 UHMG DORV ERVQV ZR RQVAGQDOVLS VR QLOEG DFK IE RVX P
 ZLG HUH UHG UR PM E R SDOQ E VEUHXQG UPLQQ HOY Q MALU
 S RLPDOQG VDDNFKPHQV Q SDH RHV NR EGHI DS VIDH
 PR EQLHG RVUG KMFQMU QG HDS SRUPDAG QMM RGLQH ZLV
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 QNDORGV



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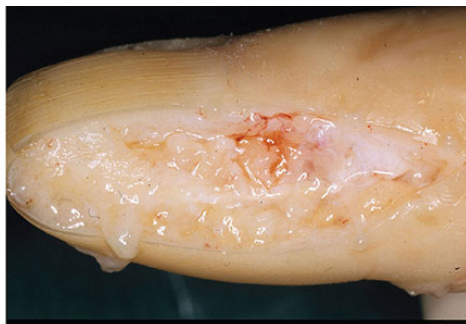
C

) LXXH \$ 1 DCEGH FMRQZWKIDS UHSDU' HFWWUUPRYDRI H RMMV %) OS
UHSDU5HGAVQRI WHVJHR WHGHFWA WRP DODMDEUGHIOSV & \$SSHUQFH
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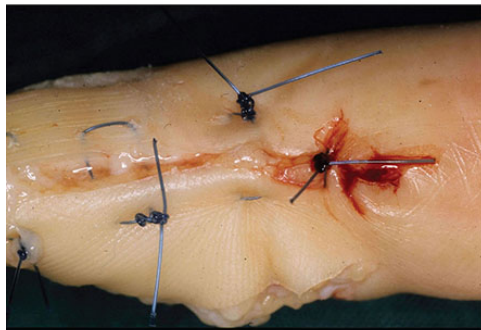
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FDUQR PD RV ELGH IDS RFPV UR PM B ZHWSUR M DNDOR G
DQG UR PM SOS VJ IY DG RWSIHAV R M M GHFWR QM EGH QD
LVV XJHG RMM/DND DS FVR M SDN RH GHFWR QM SOS VL
DOR ZG RWHOE VFR Q D QANR Q



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) L X U H \$ \$ S S U R F K V W H E I G H I O S X H G V R F O M H Z I G H O M D O G H F W K H U G H V R
 V T X P R X V F H O F D U L Q R P D I Q W A R W H O M D O Q D O X Q W % \$ S S D U Q F H D W U F O D U P D J I Q Z H U H
 F E M Q G X M Q I O R K V P I F U R J U S K E V A J H U & & O X U H Z W D E I G H I O S I U R W H S X S '
 \$ S S D U Q F H D W P R Q M V S R W A S H U M H O (8 S S H Y M E Z V K Z I Q W H S H U P D Q Q M Q U R Z I Q F I W H Q D O
 X Q W

Grafts

* U D W Q I V H T X U G I V A U I Q E R O N H M F W R Q R M A Q L O X Q W H A U U R P D
 V T X P R X I F O I E U L Q R P D R U R P H O Q R P D Q W A V D I S X A R Q V Q W
 P D Q G V A U Q M A H Q X D Q F V) L J \$ ± &

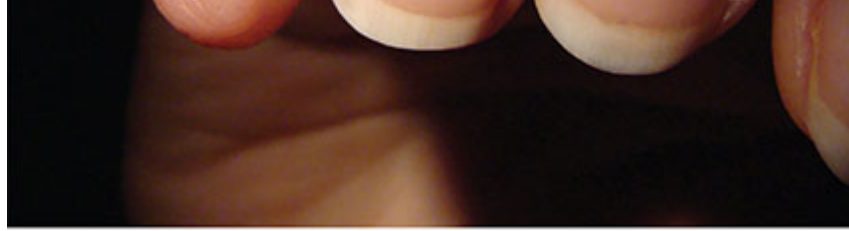


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) LXXH \$) XOMENQW/VNQJUDWRUHSUR H FMRQR PHQPPDIQVW 0 HDQPPDIQVW
R VHVFRQGIQIHU % \$ SSHDQFHIPPHGDMD SRVSHUDMHD DVAUSQPHQV DIXOMENQW
VNQJUDW & &QFDDSSHDDQFHRI VFRQGGJWDV \HUIRQZ XSDVWVHSDPHQV IXD
MENQW/VNQJUDW

* UDWQI VR OG HQHDD RQ E HR QG HIG RIQHUV ENLQI VR PH
XQG HQLQI VR VVXHX Q MA JUDWV DPXW VEFDNFLDOMVXH G HULQI RV
VH E R \$DDQI FD E YUH XFR PR VIE IZKQ XLQI LQIHUV R UDFQDC
VAN RH JUDWV XXDD IUY MAG UR PMA S MDMDODP Q DE QDU
E BLIQI IDH XFK IV MA QALQD DS FVR MA S SHDP 'HDWQI VR OG
QR VE HR YOH DUHMY HQ RGHVR BQLQI VR PH SGGIL Q MA RVM
VFR Q ID QAQR QKDDQI V EVW VEFNUR OG GHPID VZHDV GUEW
S HXUXH UR PVR M QG UR PS RLV IYUR ID R PDNR QQR WQZ DV
QDG VV HUR IV QG RVR RVMV V JQHDD R BV IR ELQ

Nail Bed Reconstruction

/ DM HFR QVVR QR MA QLOEG VQ KDV ZV VDUQI QG QNR S K
: R OG VAV MQ P Q MALU ERUG VVGPILQR QEQ E HAVR HDE \
VFR Q ID QAQR Q BVRA WQ HXVMQ VDUQI QG QGIRILW
' HFAW PHXULQI RV PP EQ E HER NG ZX DMDO G YQPHQVDS V
PR ELHG RVZUG KMFQNU E MA XH R HDLQI QFVR Q Q MA DMDO
S UR QKDDOR GWH IE R Y H

' HFAW JHDAU MQ P EQ E HMDAG ZX DS KVMFNQW QLOEG
JUDWVY MAG UR PDW YME IZGIV \$ S V R KVMFNQW QLOEG
JUDWS RV PPQ GDRHNU ZQVSIEDO XUY Y HY IZKQ SDHG
GUEW RVQ KME R \$DDQI 7KH FLQ GQZE EN R VFK MKQT XV V
VDMMA RNDQ QG RH DEZ GHEWR QQRNU QLO R RVRPH MV
LQR Q ELQH R PH XJHR Q IUY MXPFR X FPE QH UR PMA IUG
S DM QG UDWVRVQ KM/QLOEG ZX JR R GAV

32 672 3(5\$7,9(&2 16,' (5\$7,2 16

6XJLFDO SDQQJ QFOG V I QNALS DR QR IQG ESUDNR QR US RRVSUBNY H
FR QG HNR Q BNFQW EY HMA IQF ZW DSG GH EQDH Q SDH
) LJ \$ QRILFH GHULQ IQQH DW RN/ S RRVSUBNY Q VR Ø
E HRIHUG QG KZH R PH SWQV IS SHIDM MW R WSWQV RR RV
LQNDG RWKEQH MA GHULQ DMR PH :UWQ QXKFWR Q DH SRJGLE



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) LXXH \$ %& \$ JJUWYHEDQEDJQJ KHSVPDQMQIPPREQW

3DLQ FDDJHPHQW/ Q PS RQDNR QHQ DNJ XJHU W/ PS RQDNR
WJHW R/ SWQW KDMQY DR QR M XJLFDO W DG RQ ZQ DNY W
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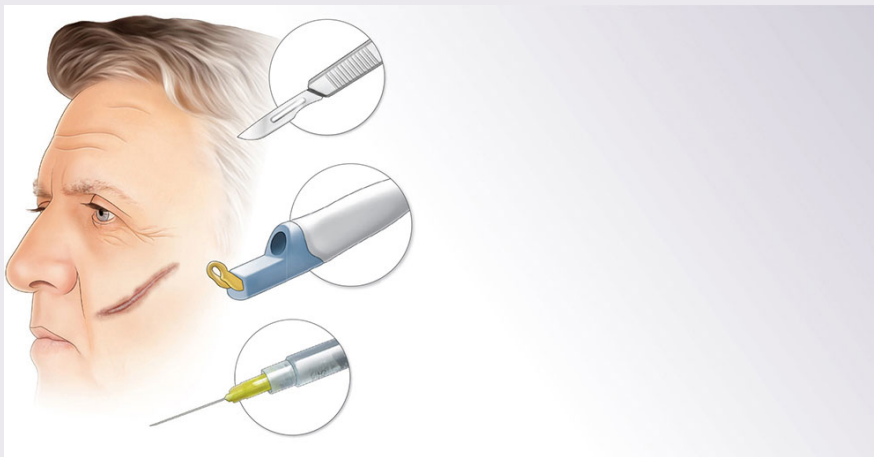
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CHAPTER 35 Surgical Scar Revision

Mary L. Stevenson
John A. Carucci



SUMMARY

- Cutaneous scars are a critical consideration for the dermatologic surgeon, as patients often judge the ultimate success of their surgery based on the final appearance of the surgical scar.
- Numerous techniques are available for surgical scar revision, ranging from topical therapy to laser treatment to surgical intervention.

- Timing of scar revision is usually planned several months following surgical intervention to allow for the scar to improve naturally, though in some instances—such as cases of hypertrophic scarring and keloid formation—more rapid intervention may be appropriate.
- Minimally invasive approaches, such as topical and laser therapy, may be considered sooner.

Beginner Pearls



- The majority of favorable scars are produced within RSTLs.
- Scars continue to mature and remodel for up to 12 months, and the appearance of scars continues to improve even beyond one year.
- Intralesional corticosteroids are the mainstay of treatment for hypertrophic and keloidal scars.

Expert Tips



- The 585-nm pulsed dye laser (PDL) was the first laser to gain wide acceptance for use in treating scars postoperatively, though the 532-nm KTP laser or IPL may also be used for erythema in surgical scars.

- Fusiform excision, Z-plasty, V–Y advancement flaps, and subcision may all be used to improve scar cosmesis as well.

Don't Forget!



- Patients who are pregnant or immunosuppressed should not be injected with 5-FU.
- Fractional ablative and nonablative laser resurfacing has also been used for scar revision.
- Dermabrasion is often performed 4 to 8 weeks postoperatively when tissue remodeling is taking place, though it may also be used significantly later.

Pitfalls and Cautions



- Ultimately, tension is the greatest enemy of the surgeon, and excess tension is responsible for many scar-related complications.
- Therefore, meticulous surgical design coupled with outstanding suturing technique may mitigate many scarring complications.

Patient Education Points



- Explain to patients prior to any procedure that every surgical procedure results in a scar.
- Ideally, a preoperative explanation that every surgical procedure may ultimately benefit from a staged approach helps patients understand that additional treatment may be beneficial, and helps them anticipate this eventuality rather than see it as a complication.

Billing Pearls



- Z-plasty may be billed using the 140XX series codes and is often reimbursable from insurance.
- Most laser- and light-based treatments are excluded from insurance coverage.

CHAPTER 35 Surgical Scar Revision

INTRODUCTION

Cutaneous scars are a critical consideration for the dermatologic surgeon, as patients often judge the ultimate success of their surgery based on the final appearance of the surgical scar. Revision of surgical scars is sometimes necessary for functional reasons, aesthetic reasons, or both. Numerous techniques are available for surgical scar revision, ranging from topical therapy to laser treatment to surgical intervention. Consideration of the texture, contour, erythema, hypo- or hyperpigmentation, and quality of the scar will affect the revision technique employed. Knowledge of these techniques allows the surgeon to achieve the best results for their patient. An appreciation of relaxed skin tension lines (RSTLs) is essential to understanding scars and scar revisions, as the majority of favorable scars are produced within RSTLs. Scars continue to mature and remodel for up to 12 months, and the appearance of scars continues to improve even beyond 1 year.¹ Timing of scar revision is usually planned several months following surgical intervention to allow for the scar to improve naturally, though in some instances—such as cases of hypertrophic scarring and keloid formation—more rapid intervention may be appropriate. Minimally invasive approaches, such as topical and laser therapy, may be considered sooner.

In an effort to standardize treatment of scarring, the International Advisory Panel on Scar Management released a consensus statement on the management of scars in 2002 consolidating evidence-based medicine and expert opinion.² In 2014, updated recommendations were published and since then further technologies and data have been released.^{3,4} These

recommendations include topical therapies, intralesional agents, laser therapy, and radiation therapy for the treatment of scars. Surgical revision may also be employed.

INTRALESIONAL APPROACHES

Intralesional corticosteroids are the mainstay of treatment for hypertrophic and keloidal scars.^{2,5} Injection of triamcinolone acetonide has been an evidence-based approach since 1966 when the first controlled study of its use was reported.⁶ Used in concentrations ranging from 10 to 40 mg/mL, it can also be combined with intralesional 5-fluorouracil (5-FU), laser therapy, or surgical intervention with injection at the time of treatment to prevent keloidal scar formation (Table 35-1). Adverse effects of intralesional corticosteroid injection include atrophy, telangiectasia, and hypopigmentation.

Table 35-1. Intralesional Options

Triamcinolone
5-FU
Combination approaches

In 1999, Fitzpatrick reported on nine clinical years of experience of injection of 5-FU for the treatment of hypertrophic and keloidal scars.⁷ Patients were treated with 5-FU at a concentration of 50 mg/cc with doses ranging from 2 to 50 mg per treatment with injections occurring up to three times weekly, with reduction in frequency to every 4 to 6 weeks following the improvement of scars. He also combined 0.9 cc of 5-FU at 50 mg/cc and 0.1 cc of triamcinolone acetonide at 10 mg/cc and found these injections to be less painful. Re-excision of keloids with intraoperative intralesional 5-FU and/or triamcinolone is also highly effective (Fig. 35-1).⁸ Patients who are pregnant or immunosuppressed should not be injected with 5-FU.



Figure 35-1. Removal of keloid followed by injection of triamcinolone plus 5-fluorouracil: (A) preoperative view; (B) postoperative view. Patient underwent monthly injections of triamcinolone and 5-fluorouracil for 4 months.

LASER- AND LIGHT-BASED APPROACHES

The original 2002 scar management consensus guidelines addressed CO₂ lasers, argon lasers, and pulsed-dye laser (PDL) therapies. Since then, numerous other therapies have emerged including ablative and nonablative fractional lasers. [Table 35-2](#) is a summary of minimally invasive approaches to scar revision.

Table 35-2. Minimally Invasive Approaches to Scar Revision

CO ₂ laser
Pulsed-dye laser
IPL
Dermabrasion
Nonablative fractional resurfacing
Ablative fractional resurfacing
Microneedling

The 585-nm PDL was the first laser to gain wide acceptance for use in treating scars postoperatively.^{4,9} The PDL targets oxyhemoglobin as its chromophore, and is effective in targeting small blood vessels within scar tissue, improving erythema. This approach may also be used after superficial flap necrosis (Fig. 35-2). Additionally, PDLs have been used for hypertrophic scars and keloids, leading to possible improvement in scar pliability.⁹ While the exact mechanism of action has yet to be elucidated, it is postulated that microvascular destruction and tissue ischemia may lead to collagen remodeling, and that PDL treatment may reduce the higher levels of transforming growth factor-beta which is found in keloids.^{10,11} Sub-purpuric settings with longer pulse durations and lower fluences may demonstrate superior outcomes to purpuric settings in surgical scars, though both are effective.^{10,11} Adverse effects include erythema, swelling, ecchymoses, and hypopigmentation. Alternatively, the 532-nm potassium titanyl phosphate (KTP) laser or intense pulsed light (IPL) may also be used for erythema in surgical scars.



Figure 35-2. PDL for telangiectasia and erythema after flap necrosis. (A) Defect after cancer removal. (B) Rotation flap repair. (C) Distal necrosis at suture removal. (D) Result after conservative wound care and three treatments with PDL.

Introduced in 1953, dermabrasion is another useful modality for treating surgical scars.¹² Dermabrasion is often performed 4 to 8 weeks postoperatively when tissue remodeling is taking place, though it may also be used significantly later.^{13–15} The most common adverse effects include hypo- and hyperpigmentation, persistent erythema, infection, viral reactivation, and rarely keloid formation. Following dermabrasion, ablative resurfacing with high-energy, short-pulsed CO₂ lasers or low-power continuous-wave CO₂

lasers was popular as an effective means of skin resurfacing, though they have significant healing time and postoperative wound care.^{16–18} In comparison to dermabrasion, ablative CO₂ lasers offer the advantage of a bloodless field and increased precision with more selective tissue ablation.¹⁹ However, patients experience crusting, oozing, and often persistent erythema with re-epithelization at approximately 1 week and erythema persisting for 4 to 8 weeks. Adverse effects include hypo- and hyperpigmentation, milia formation, infection, viral reactivation, and scarring.

More recently, fractional ablative and nonablative laser resurfacing has been used with increasing frequency for scar revision. In fractional resurfacing, the laser creates microthermal zones (MTZs) of injury just below the skin surface, with selective necrosis and neocollagenesis.²⁰ This technology specifically spares the tissues surrounding each individual microscopic wound, which allows for faster healing and less downtime. The 1550-nm erbium-doped fiber laser, which utilizes nonablative fractional resurfacing, was shown to be effective in surgical scars.²¹ In a split-scar study comparing nonablative fractional resurfacing with PDL following Mohs micrographic surgery, nonablative fractional resurfacing showed improved outcomes for overall cosmesis, dyspigmentation, hypopigmentation, thickness, and texture of scar.²² The most common posttreatment events include dry and flaking skin, erythema, edema, acneiform eruption, and viral reactivation, with healing occurring within 1 week.^{23,24} Ablative fractional resurfacing has been used as well.^{25,26} Sparing surrounding areas of tissue, ablative fractional resurfacing allowed for re-epithelization and resolution of erythema within 7 days, with deeper zones of tissue ablation.^{26,27} Ablative fractional resurfacing may be more effective than nonablative fractional resurfacing, and has shown utility in thicker and atrophic scars.^{1,27,28} A small series of atrophic scars showed that three ablative fractional resurfacing treatments at 1- to 4-month intervals resulted in a 38% mean reduction in scar volume and 35.6% mean reduction in maximum scar depth.²⁷ In comparison to PDL, which is more effective at improving vascularity within scars, ablative fractional resurfacing demonstrates superior results in improving scar contour, including scar thickness and pliability.²⁹ In a postthyroidectomy surgical scar study comparing fractional ablative laser resurfacing to nonablative fractional

laser resurfacing, fractional ablative laser resurfacing tended to improve scar thickness, while nonablative fractional laser resurfacing was superior at improving scar color including erythema and pigmentation.^{30,31} This benefit should be weighed against the increased downtime seen with ablative approaches.

Finally, microneedling and microneedle fractional radiofrequency have also been used to improve the functional and aesthetic outcomes of surgical scars. Subcision, with the insertion of a needle through punctured skin for the correction of depressed scars, was first reported in 1995.³² A small randomized clinical trial comparing nonablative fractional laser and microneedling in atrophic acne scars showed both to be efficacious, with microneedling having fewer adverse effects including hyperpigmentation.³³ Microneedling has also been shown to increase the viability of skin flaps in animal models, though there are no reported studies of its efficacy in the treatment of surgical scars to date.³⁴ Currently on the horizon, radiofrequency microneedling has also been shown to improve acne scars by damaging the reticular dermis, resulting in tissue remodeling and the increased formation of elastin and collagen.^{35–37}

SURGICAL TREATMENT

Fusiform excision is the most basic technique for surgical scar revision. The entire length of the scar is excised with as narrow a margin as possible resulting in a longer—and ideally narrower—scar (Fig. 35-3).¹ Such revised fusiform excisions generally have a length-to-width ratio well in excess of 3:1, with 30-degree angles at the apices. In lieu of complete scar excision, partial removal can alternatively be performed, as in the case of the standing cone revision (Fig. 35-4). Table 35-3 is a summary of surgical approaches to scar revision.

Table 35-3. Surgical Approaches to Scar Revision

Fusiform excision
Z-plasty
W-plasty
V-Y advancement flap
Subcision



A



B

Figure 35-3. Scalpel revision for disunion of the nasal tip. (A) Preoperative view following referral for disunion at nasal tip following graft failure. (B) Postoperative view following excision of scar and primary closure.



Figure 35-4. Scalpel revision of standing cone. (A) View at closure of defect from Mohs for incompletely excised BCC on the lip. (B) Standing cone on inner lower lip covered teeth with full smile. (C) Immediate postoperative view following excision of standing cone.

Z-plasty is another commonly employed technique that reorients the direction and tension vectors of a scar, allowing it to be aligned within RSTLs (Fig. 35-5).³⁸ It is indicated for webbed scars, contracted scars, and scars that are greater than 30 degrees from the RSTLs.³⁹ In this technique, the original scar forms the common diagonal, and two arms of equal length to the original scar are extended in either direction at a set angle.⁴⁰ The original scar is then excised, with incisions made along arms of the Z, with subsequent undermining and transposition of the two triangular flaps to create a new scar perpendicular to the original one. The size of this angle and the length of the original scar determine how much scar lengthening will occur

when the tension is redirected, with larger angles producing a greater lengthening in the scar as well as a greater reorientation of the direction of the scar. The traditional angle of 60 degrees lengthens the scar by 75%. Multiple Z-plasties may also be used in succession for longer scars. For a detailed discussion of Z-plasty techniques, see [Chapter 27](#).

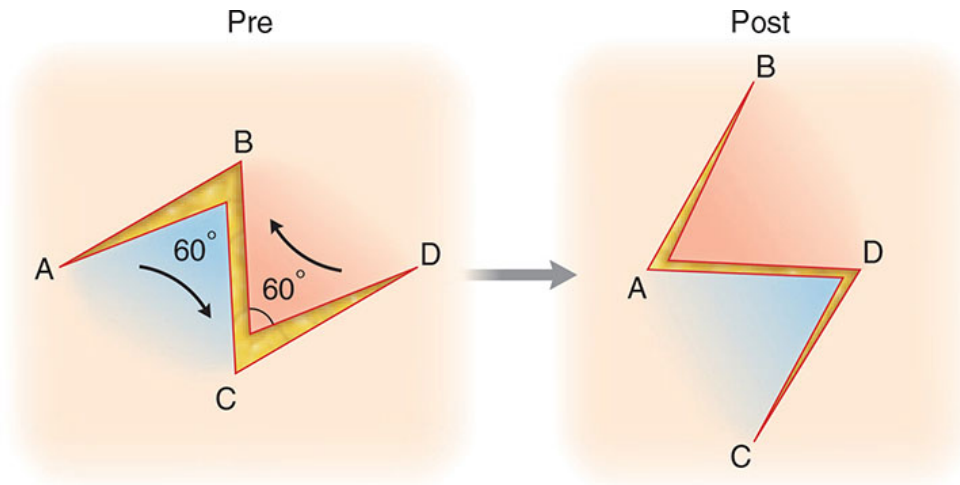


Figure 35-5. In a Z-plasty, two arms of equal length to the original scar are extended in either direction at a given angle. The original scar is then excised with incisions made along these arms followed by transposition of these two triangular flaps to create a new scar that is perpendicular to the original one. This results in scar lengthening and is thus useful for correction of webbing and free margin distortion.

In comparison, the W-plasty technique does not result in the lengthening of the original scar and involves the creation of multiple, short, connected, triangular advancement flaps that run along the length of the original scar ([Fig. 35-6](#)). This technique is often employed for shorter scars located on the forehead or cheek with an M-plasty at the end of the incision to prevent scar extension.⁴¹ Additionally, in comparison to the Z-plasty which involves excision of the scar and incisions along the arms, the W-plasty involves the excision of the scar and a small amount of surrounding normal skin.³⁹ A more complex variation of the W-plasty is a geometric broken line closure in which a random pattern of geometric patterns is interposed in order to create a random irregular scar.^{39,41}

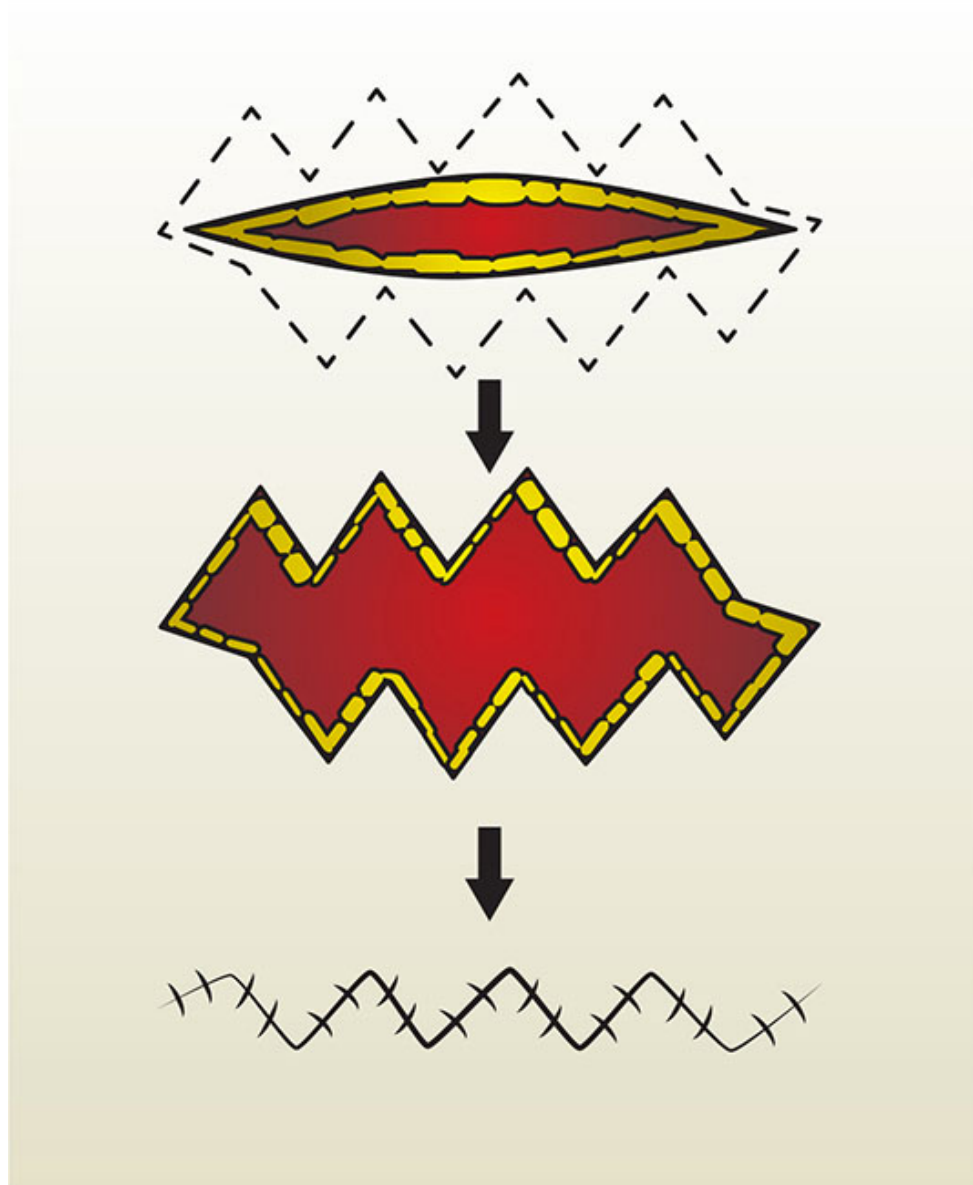


Figure 35-6. W-plasty technique involves the creation of multiple, short, connected, triangular advancement flaps that run along the length of the original scar. This does not result in lengthening of the scar as is the case with Z-plasty.

A V–Y advancement flap may be used at free margins such as the lip or eyelid in order to correct contraction which may result in elevation or depression of the tissue.⁴⁰ This technique may be used to correct ectropion on both the upper and lower eyelids.⁴² A V-shaped incision is made surrounding the contracted scar, with wide undermining performed circumferentially. This V-shaped pedicle is then *pushed* forward by side-to-

side closure of the tail of the Y posterior to the now-advanced pedicle, altering the tension on the contracted scar and allowing for an improved cosmetic outcome ([Fig. 35-7](#)).⁴⁰



A



B





Figure 35-7. Rotation flap with back cut and periosteal anchoring suture to correct medial lower lid ectropion. (A) Preoperative view with ectropion resulting in tearing. (B) Immediate postoperative view. (C) Patient achieves normal eye closure with resolution of tearing.

Subcision may be performed to achieve ideal contour in cases of trapdoor deformity. An incision is made at the distal edge of the elevated flap (Fig. 35-8). Undersurface debulking is performed followed by re-approximation of the flap. Concavity revision may be more challenging, though a free cartilage graft may be used to raise the nasal tip to improve the appearance of a failed full-thickness skin graft (Fig. 35-9).



A



B





C

Figure 35-8. Subcision technique for revision of trap door deformity. (A) Trap door deformity at distal portion of paramedian forehead flap. (B) Area is incised, elevated, and deep aspect of the bulky area is thinned. (C) Flap is reapproximated after placement of buried absorbable suture to recreate the alar crease.



A



B



C



D

Figure 35-9. Placement of a free cartilage graft to restore contour. (A) Preoperative view after referral for revision following failure of skin graft. (B) Free cartilage graft was obtained from the antihelix. (C) Graft was placed after incision and elevation of site. (D) Contour improvement at 2 months.

CONCLUSIONS

Scars are an inevitable consequence of cutaneous surgery. The goal of surgical scar revision is improved functionality and cosmesis. Consideration of the type of scar, location of the scar, quality and texture of the skin, RSTLs, and other considerations are all essential in planning an ideal revision. Notably, regard for tension on the healing wound is of paramount importance. Use of nonsurgical and surgical techniques often leads to the most ideal revision. Meticulous planning, including an appreciation of the timeline for various scar revision techniques, is also essential. By appreciating the ever-expanding armamentarium of surgical scar revision techniques, the surgeon may better care for their patients and produce optimal outcomes.

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CHAPTER 36 Managing Surgical Complications

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SUMMARY

- Dermatologists perform approximately 9.5 million procedures yearly in the United States alone.
- The rate of complications remains under 1%, and the rate of serious complications is vanishingly rare.
- The risk of bleeding is the greatest in the first 24 hours postoperatively and is most frequent in the first 6 hours.

- Prophylactic antibiotics are only indicated in specific circumstances (surgery on the mucosa or infected skin) to prevent joint infection, endocarditis, and surgical site infection.

Beginner Tips



- Be able to recognize signs and symptoms of vasovagal reaction, epinephrine reaction, anesthetic overdose, and anaphylaxis.
- To avoid a delayed suture reaction, or spitting suture, place absorbable sutures deep in the dermis, cut sutures at the knot, and close wounds with minimal tension.

Expert Tips



- Digital blocks with lidocaine with epinephrine are considered safe, though the surgeon should avoid using more than 2 to 4 mL of anesthesia per digit, as the mass effect of the anesthetic volume added can lead to nerve and artery compression.

Don't Forget!



- The nerves at the greatest risk for injury during cutaneous surgery are the temporal and marginal mandibular branches of the facial nerve and the spinal accessory nerve. Know the anatomical danger zones of these nerves, but also appreciate that nerve location cannot be precisely identified by anatomic location due to extensive individual variability.

Pitfalls and Cautions



- Poor closure design can lead to tension on an anatomic free margin and subsequent cosmetic and functional impairment. The surgeon should design closures that place tension perpendicular to the free margins.

Patient Education Points



- While complications in dermatologic surgery are uncommon, even a 1% complication rate translates into a risk of possibly weekly complications given the volume of procedures performed by many dermatologic surgeons.
- Taking time to actively consent patients and inform them of possible complications may lead to a significant improvement in patient satisfaction.

Billing Pearls



- Dermatologic surgeons should be familiar with global periods; most complications treated within the global period of a given procedure cannot, by definition, be billed for separately.
- Weigh the value of charging patients for revision procedures against the goodwill fostered by performing these procedures as a courtesy.

CHAPTER 36 Managing Surgical Complications

INTRODUCTION

Dermatologists perform approximately 10.5 million procedures each year.¹ Of these, about 68% are cosmetic procedures and the remainder are procedures such as Mohs micrographic surgery (MMS) and surgical excisions.¹ The vast bulk of dermatologic surgery is performed in an outpatient, office-based setting.

The safety and efficacy of dermatologic surgical procedures has been supported by multiple clinical studies. A prospective study following 2370 surgical procedures, including 934 MMS cases, over a 1-year period found a total of 56 surgical complications in 51 patients. Bacterial wound infections occurred in 13 cases (0.5%) and bleeding complications occurred in 5 cases (0.2%).² A prospective multicenter study examined the intraoperative and postoperative adverse events at 23 centers performing MMS. Among 20,821 MMS procedures, there were 149 adverse events (0.72%), including 4 serious events (0.02%), and no deaths were reported. Of the adverse events, 61.1% were infections, 20.1% were wound dehiscence or partial- or full-depth necrosis, and 15.4% were related to bleeding or hematomas.³ Even for staged interpolation flaps, among the most invasive of dermatologic surgery procedures, the complication rate remains quite low. A review of 653 staged interpolation flaps at a single center revealed no major complications. Minor complications consisted of active bleeding requiring physician intervention (8.4%), hematoma (0.4%), postoperative infection after initial surgery (1.7%), and after division of pedicle (3.4%), dehiscence (0.5%), and partial- (2.3%) or full-thickness (0.6%) flap necrosis.⁴ Noninvasive to

minimally invasive cosmetic dermatologic procedures are also associated with a low rate of adverse events. A multicenter, prospective cohort study of procedures performed using laser and energy devices, injectable neurotoxins, and soft-tissue augmentation materials (20,399 total procedures) reported only 48 adverse events (0.24%) and no serious adverse events.⁵

Overall, the risk of minor adverse events in dermatologic surgery is low, and severe complications such as hospitalization and death almost never occur. Nonetheless, complications still arise in dermatologic surgery and surgeons must be able to successfully prevent, diagnose, and manage these complications. This chapter will address preoperative techniques to minimize adverse events in dermatologic surgery, as well as the identification and management of complications in the intraoperative and postoperative time periods.

PREOPERATIVE CONSIDERATIONS

The preoperative risk for surgical complications is a function of patient factors, including medical comorbidities, medications, and behaviors, and the procedure being performed. The degree of preoperative assessment should be dictated in part by the extent of the procedure. Dermatologic procedures such as cryotherapy and shave biopsies are low risk, while flaps, grafts, MMS, and large excisions are considered higher risk. Patient risk factors may impact the surgeon's choice of surgical modality or the type of surgical reconstruction performed. Prior to the procedure, the patient should be counseled in detail on the expected postoperative course, including activity limitations, wound care, pain control, and medication management.

A thorough preoperative evaluation includes a medical history and physical examination. Diabetes, hypertension, liver failure, renal failure, immunosuppression, inherited bleeding disorders, inflammatory skin conditions, and prior radiation therapy are examples of conditions that can complicate dermatologic surgery.⁶ A thorough list of medications and supplements should be collected; many medications may impact intraoperative and postoperative bleeding. The surgeon should also assess and quantify the patient's smoking and alcohol consumption. Alcohol use and smoking may increase the risk of complications, and even minor decreases in consumption can improve postoperative results.⁶ Identifying patients with

implantable electrical cardiac devices or other implantable electric devices can guide the safe use of electrosurgery.⁷ Allergies, particularly medication reactions and prior reactions to latex or other medical materials, should be obtained. Vital signs may be obtained on the day of surgery as part of the physical examination. While there is a range of blood pressures within which dermatologic surgeons comfortably operate, one comprehensive review suggests that for patients with a systolic pressure ≤ 180 mmHg and diastolic pressure ≤ 100 mmHg and no other medical contraindications, cutaneous surgery may proceed.⁸ Higher blood pressures often warrant surgical deferment. Many surgeons rely on patient-reported history to ascertain whether a history of uncontrolled hypertension exists. Surgery should be avoided on areas of active infection or inflammation.

INTRAOPERATIVE COMPLICATIONS

Anxiety

Anxiety in dermatologic surgery results from multiple potential factors, including concern about the risks of the procedure, separation from loved ones, unfamiliar environment, loss of control, reliance on strangers, needle phobia, cosmetic concerns, and anticipation of intraoperative and postoperative pain.^{9,10} Increased levels of anxiety may have a negative impact on the patient's surgical course. The release of epinephrine into the bloodstream causes blood vessel constriction, increased heart rate, increased blood pressure and temperature, flushing, and sweating.¹¹ These physiologic changes may result in increased intraoperative and postoperative bleeding. Anxiety has also been shown to increase postoperative pain in dermatologic surgery; Chen et al. demonstrated that higher preoperative scores on two validated questionnaires, the Pain Catastrophizing Scale (PCS) and Pain Anxiety Symptoms Scale (PASS), correlate with increased pain after MMS.¹² Anxiety can also decrease patient satisfaction.¹³ In order to minimize patient anxiety, it is key to manage patient expectations and provide clear explanations before, during, and after surgical procedures.

Before surgery, patient anxiety can be decreased by a phone call discussing the diagnosis and what to expect on the day of the surgery, as well as reading written material or searching the Internet for information regarding

the procedure.¹³ Calls from physicians, as opposed to nurses or other team members, have also been shown to be effective in reducing patient anxiety.¹³ Listening to music has been demonstrated to reduce anxiety in patients undergoing dermatologic surgery, especially those undergoing surgery for the first time.¹⁴ Eating throughout the day, watching TV, bringing a guest, and engaging in small talk with the surgeon and staff during the procedure have also been shown to subjectively decrease patients' anxiety.¹³ Other potential relaxation strategies include slower breathing, biofeedback, progressive muscular relaxation, guided imagery, hypnosis, and meditation.¹⁵

Some patients may require a preoperative oral anxiolytic such as diazepam, alprazolam, or midazolam. During MMS, midazolam has been shown to offer the benefit of amnesia, reduced alertness, and reduced blood pressure with no clinically significant adverse effects.¹⁶ In patients requiring an anxiolytic, informed consent should be obtained prior to medication administration. The patient should be accompanied to their surgical appointment and should be instructed not to operate a vehicle the day of the surgery.¹⁷ The most notable side effects of benzodiazepine use include drowsiness and respiratory depression, which require intra- and postoperative patient monitoring. It is important to note that <1% of individuals taking a benzodiazepine may paradoxically experience agitation, restlessness, hyperactivity, and combativeness, and may require flumazenil for reversal of the medication.¹⁸

Reaction to Anesthesia

Pain

Given that the majority of dermatologic surgeries are performed with the patient awake, intraoperative pain management is a key concern. For instance, while MMS is typically well-tolerated, significant intraoperative pain is one of the risk factors for aborting a case prior to achieving clear surgical margins.¹⁹ Injectable local anesthesia (LA), most commonly lidocaine, is used for intraoperative pain management in dermatologic surgery. For a full discussion of LA in dermatologic surgery, see [Chapter 12](#).

LA injection itself can be painful due to needle sticks, tissue distension, and burning associated with the anesthetic itself.²⁰ Several techniques can

help minimize discomfort during the administration of LA. First, buffering lidocaine with sodium bicarbonate in a 10:1 ratio can decrease injection site pain by alkalinizing the solution toward a more physiologic range.²¹ By increasing the pH, there is a 10-fold reduction in hydrogen ion concentration, which decreases local irritation and causes a much more rapid disbursement of the anesthetic, resulting in near instantaneous nerve blockade.^{22,23} Second, various injection techniques can be utilized for pain minimization. These include using a small bore needle (most commonly a 30 gauge), injecting slowly, topical skin cooling prior to injection, using warmed anesthesia, providing distraction stimuli with pinching or vibration, injecting perpendicularly to the skin initially, using as few needle sticks as possible, and ensuring adequate depth and width of the anesthetic.^{24–28}

The use of topical anesthetics prior to LA injection can minimize both patient anxiety and pain. Topical anesthetics may decrease the pain of the needle placement, but will not impact the pain due to anesthetic infiltration. Patients should be provided instructions on safe use of the topical medication and apply the topical anesthetic under occlusion 30 to 60 minutes before arriving for their procedure.²⁹

Topical anesthetics exist in many different preparations and vehicles for delivery. There are numerous commercially available, FDA-approved topical anesthetics for use in dermatology including:

1. Eutectic mixture of local anesthetics (EMLA; Astra Pharmaceuticals, Westborough, MA), which is an oil-in-water emulsion of 2.5% lidocaine and 2.5% prilocaine.
2. Topical lidocaine products, such as Topicaine (ESBA Laboratories, Jupiter, FL), Lidoderm (Endo Pharmaceuticals, Chadds Ford, PA), and LMX (Ferndale Laboratories, Ferndale, MI).
3. Topical S-Caine peel marketed as Pliaglis (Galderma Laboratories, Fort Worth, TX), which is a eutectic mixture of 7% lidocaine and 7% tetracaine in a cream base and topical S-Caine patch marketed as Synera (Zars, Inc, Salt Lake City, UT), which is a eutectic mixture of 70 mg of lidocaine and 70 mg of tetracaine under a patented heating element that enhances delivery of the anesthetic.

All topical anesthetics have associated risks of cardiotoxicity and central nervous system (CNS) toxicity, which are heightened with prolonged application, the use of inappropriately high concentrations, and application to a large surface area. The prilocaine portion of EMLA can induce methemoglobinemia by oxidizing iron in red blood cells from the ferrous to the ferric state, impairing hemoglobin transport of oxygen.²⁹ Very young patients or patients with glucose-6-phosphate dehydrogenase deficiencies are more susceptible to methemoglobinemia.

Non-FDA-approved, pharmaceutically compounded topical anesthetics should be used with caution. These products typically contain higher concentrations of the compounded anesthetic mixtures than their FDA-approved counterparts and lack appropriate warnings or directions for use. These factors increase both the risk of adverse events and provider liability. Practitioners may wish to limit the use of topical anesthetics to those approved by the FDA, or at least those prepared by reputable compounding pharmacies.²⁹

Local Reactions

Tenderness, bruising, and edema are commonly seen after LA infiltration. Edema is often more pronounced in the thinner skin of the periorbital area or the oral mucosa and vermillion lip (Fig. 36-1). Transient motor nerve paralysis can be seen if there is anesthetic involvement of large myelinated nerve fibers. This paralysis may persist several hours after sensory nerves have returned to normal function and patients should be counseled on this potential outcome prior to the procedure.³⁰



A



B

Figure 36-1. (A) Periorbital bruising and edema after Burow's graft closure on nose. (B) Edema bullae on the hand after rotation flap closure. Reconstruction on the hand often leads to extensive swelling; this can be minimized by wrapping the hand, including the fingers and thumb to the DIP joints, to the mid-forearm with a self-adherent wrap.

Allergy/Anaphylaxis

A rare but important side effect of LAs is allergic reaction. These reactions involve either type I (immediate) or type IV (delayed-type) hypersensitivity. Most true allergic reactions to LAs are type IV reactions, also known as contact allergy. A retrospective chart review of 1819 patients found that type IV hypersensitivity to LAs has been increasing, with benzocaine (45%), lidocaine (32%), and dibucaine (23%) as the most common allergens.³¹ This phenomenon is thought to be due to an increased number of over-the-counter products containing lidocaine, resulting in unnecessary exposure and sensitization. Type IV hypersensitivity results in a local eczematous dermatitis, characterized by erythematous papules and/or vesicles that may progress to plaques and bullae; anaphylaxis is not a risk.^{31,32} The time course of type IV hypersensitivity is most commonly at least 48 hours after exposure.

In contrast, type I reactions are IgE-mediated and occur minutes to hours after exposure to an antigen. Local manifestations of type I hypersensitivity are isolated urticaria or angioedema without laryngeal involvement. Systemic manifestations, or anaphylaxis, include bronchospasm and peripheral vasodilation, presenting as tachycardia and hypotension (Table 36-1). Overall, the rate of true IgE-mediated allergy to LAs in very high-risk populations (patients reporting an LA allergy) has been found to be around 1%.³² Thus, the prevalence of IgE-mediated LA allergy in the general population is presumably significantly lower. While latex, found in surgical gloves, was previously one of the most common causes of anaphylaxis in the medical setting, widespread efforts to reduce latex exposure and sensitization have resulted in a marked decrease of the number of reactions.³³ Reports of anaphylaxis due to antibiotics, dyes, and chlorhexidine have been increasing in frequency.³³

Table 36-1. Distinguishing Reactions to Local Anesthetics in Dermatologic Surgery

	Anaphylaxis	Epinephrine Sensitivity	Vasovagal Reaction
Signs	Tachycardia + hypotension	Tachycardia + hypertension	Bradycardia + hypotension
Management	IM epinephrine 0.3–0.5 mg q5 minutes	No treatment. Nonselective beta blocker if needed.	Trendelenburg position. Atropine 0.4 mg SC if needed.

There are two classes of commercially available LAs: amides and esters. True type I allergy to amide anesthetics, including lidocaine and bupivacaine, is exceedingly rare. Most true LA allergies have been reported with ester anesthetics, including procaine, tetracaine, and benzocaine. The ester anesthetics more commonly elicit an allergic reaction because they are *p*-aminobenzoic acid (PABA) derivatives. There is no cross-reactivity between amide and ester anesthetics, but the preservative methylparaben, used as a stabilizer in multiple-dose vials of lidocaine, is structurally related to PABA. Thus, PABA and other preservatives, including sodium metabisulfite, are likely the most common cause of a reported allergy to amide LAs.^{34–36} Single-dose vials of lidocaine are available without preservatives.

If a history of type I LA allergy is documented, patients can be referred to an allergy specialist for evaluation. If an LA allergy is reported but considered low risk based on patient history, an intradermal or subcutaneous challenge can be performed in the office. This assessment is performed by injecting into the skin a 2- to 3-mm superficial bleb of a 1:1000 dilution of an LA (without epinephrine) from the opposite class as the suspected allergen. In addition, a positive control (0.10 mg/mL of histamine base) and negative control (normal saline) should be injected for comparison. The wheal and flare reaction should be evaluated at 15 to 20 minutes and, if the longest diameter of the wheal is at least 3 mm greater than the negative control, the test is considered positive. If the result of the 1:1000 dilution is negative, an increased concentration of 1:100 should also be tested before deeming the test negative. If negative, a subcutaneous challenge can then be performed with an undiluted concentration of LA.³²

It is important to be able to differentiate an anaphylactic reaction to LA from the much more common vasovagal and epinephrine reactions, which are frequently interpreted by patients as an “allergy” to LA. When a patient has systemic symptoms after the administration of an LA, a set of vitals should be taken, as well as a thorough review of systems.

With true anaphylaxis, tachycardia is coupled with hypotension. The patient may have bronchospasm, urticaria, angioedema, or other systemic symptoms such as nausea, vomiting, and diarrhea. Intramuscular epinephrine should immediately be given for anaphylaxis and the threshold for administration should be low. Treatment with antihistamines or steroids is inappropriate in cases of suspected anaphylaxis. The recommended dosing for an adult is 0.3 to 0.5 mg (this typically equals the same volume: 0.3 to 0.5

mL of a 1 mg/mL solution) of a 1:1000 solution delivered intramuscularly. This injection may be repeated every 5 minutes as needed. For a child, the recommended dosing is 0.01 mg/kg up to the adult dose of 0.5 mg. Commercially available auto-injectors deliver a preset dose of epinephrine. Dermatologic surgeons should have epinephrine solution or epinephrine auto-injectors readily available to treat suspected anaphylaxis.

If the patient is having a benign reaction to epinephrine, tachycardia with hypertension is expected. The most commonly used concentrations of epinephrine in dermatologic surgery are 1:100,000 and 1:200,000 for LA and 1:1,000,000 to 1.5:1,000,000 for tumescent anesthesia.³⁷ Even the low concentrations of epinephrine in these formulations can cause systemic effects, such as palpitations, flushing, and a feeling of panic. Epinephrine effects typically resolve spontaneously and usually do not require treatment. If needed, the recommended treatment is a non-selective beta-blocker.³² Patients can interpret the epinephrine response as anxiety or a cardiac complication, so it is important to provide reassurance as to the benign and temporary nature of this reaction. Epinephrine should be avoided in patients who have a medical history of uncontrolled hyperthyroidism or pheochromocytoma.³² Local infiltration with epinephrine has been used safely for dermatologic procedures in patients with stable cardiovascular diseases including hypertension, ischemic heart disease, arrhythmia, coronary artery disease, and heart transplantation. If there is any concern about a patient's ability to safely undergo a procedure due to cardiovascular disease, the patient's cardiologist should be consulted.³⁷

In a vasovagal reaction, bradycardia and hypotension are typically seen. This will be the most commonly encountered scenario in clinical practice. Vasovagal reaction is due to the activation of the vagus nerve in response to anxiety, fear of needles, or pain on injection, and results in heightened parasympathetic tone.³⁸ The patient will likely describe sweating, nausea, and hyperventilation.³² Patients may feel like they are about to lose consciousness (presyncope) or lose consciousness (syncope). Patients who experience syncope may lose bladder control and have rhythmic movements that can mimic a grand mal seizure.³⁹ One study revealed that young patients are more likely to experience presyncope compared with older patients, and that young males are most prone to develop true syncope.⁴⁰ If the patient is having a vasovagal response, reassurance, placing a cool towel on the

forehead, and placing the patient in Trendelenburg can alleviate the symptoms. For vasovagal reactions not responding to these measures, atropine 0.4 mg delivered subcutaneously can be considered.³² Given the risk of vasovagal reactions, it is helpful to always infiltrate LA with the patient in a supine position.

Overdose

Life-threatening systemic toxicity can potentially occur when LAs exceed their maximum dosage, or when excretion is impaired. Lidocaine has a maximum, weight-based dose of 4.5 mg/kg without epinephrine and 7.0 mg/kg with epinephrine.³⁷ Lidocaine toxicity is rare in dermatologic surgery; a 2010 study demonstrated that perioperative peak lidocaine levels during MMS do not result in serum levels approaching toxic limits, even when relatively high total lidocaine doses (up to 50 mL) are used.⁴¹ Despite this finding, toxicity has been reported as a complication of dermatologic surgery, and it is important for dermatologic surgeons to be aware of the signs, symptoms, and management of LA toxicity.^{42,43} Inadvertent intravascular administration of local anesthetic may cause systemic toxicity more commonly than gross excess of infiltrated anesthetic.^{42,43}

Overdose of lidocaine results in CNS toxicity and cardiovascular toxicity due to decreased cardiomyocyte contractility (Table 36-2). Initial signs and symptoms of lidocaine overdose occur at blood concentrations of 1 to 6 µg/mL and include perioral and digital numbness or tingling, restlessness, and lightheadedness. The patient may be increasingly talkative and describe a metallic taste in their mouth. At a concentration of 6 to 9 µg/mL, the patient may experience nausea, vomiting, twitching, tremors, blurred vision, tinnitus, and confusion. While the patient may still have a normal pulse and blood pressure, consider treating with benzodiazepines or barbiturates and ensure the airway is patent. At a blood concentration of 9 to 12 µg/mL, seizures may occur. Anticonvulsants may be used prophylactically in this situation. Additionally, initial manifestations of cardiovascular compromise may be seen, with the patient having lower than normal pulse and blood pressure. At >12 µg/mL blood concentration, the patient is at risk of coma and cardiopulmonary arrest.⁴⁴

Table 36-2. Signs of Lidocaine Toxicity

Blood Level (µg/mL)	Clinical Signs
1–6	Perioral/ digital paresthesias, restlessness, lightheadedness
6–9	Nausea, vomiting, twitching, tremors, blurred vision, tinnitus, confusion
9–12	Seizures
>12	Coma, cardiopulmonary arrest

Bupivacaine has a maximum, weight-based dose of 2.5 mg/kg without epinephrine and 3.0 mg/kg with epinephrine.³⁷ Of the non-lidocaine LAs, bupivacaine exhibits the smallest therapeutic range. Acutely elevated plasma levels may result in ventricular tachyarrhythmias and asystole, even before CNS symptoms develop.⁴⁴ If there is any concern for LA overdose of any type, anesthesia administration should be stopped and vital signs obtained. Dermatologic surgeons should have a low threshold for a transfer to a higher level of care in these cases, given the potential morbidity and mortality of anesthetic toxicity.

Digital Anesthesia

There is a historically entrenched belief that epinephrine can cause tissue ischemia and necrosis due to vasoconstriction of end arteries via alpha-1 receptors, particularly of the digits.⁴⁵ In recent years, research and reviews have invalidated this doctrine, and current evidence demonstrates that LA with epinephrine is safe for use in all clinical locations, including the digits. One study demonstrated no digital necrosis using 0.5% lidocaine with epinephrine 1:200,000 for digital anesthesia in 63 cases, including patients with peripheral vascular disease, hypertension, and diabetes mellitus.⁴⁶ Another study examined patients who accidentally injected themselves with an epinephrine pen used for anaphylaxis. No cases of digital gangrene were noted, and the epinephrine concentrations used in epinephrine auto-injectors are much higher than those used in LA for cutaneous surgery.⁴⁷ Phentolamine is a reversible nonselective alpha-adrenergic antagonist recommended for epinephrine-induced digital vasospasm, although its use after dermatologic surgery has not been reported.^{48–51}

Digital blocks can be safely performed with LA with epinephrine. The surgeon should avoid using more than 2 to 4 mL of anesthesia per digit, as the mass effect of the LA volume can potentially lead to nerve and artery compression. Circumferential ring blocks should also be avoided for this same reason.⁵² It is important to note that tubular dressings, rather than epinephrine or large volumes of LA, are the most common cause of iatrogenic digital ischemia and necrosis, due to a tourniquet effect.^{53–56}

Intraoperative Bleeding

Dermatologic surgeons must consider therapeutic antithrombotic medications, herbal supplements, inherited hemorrhagic disorders, and other comorbidities that may place a patient at higher risk of intra- and postprocedural bleeding (Table 36-3).⁷ Many patients, particularly those undergoing treatment for skin cancer, will have medical conditions that require therapy with anticoagulant and antiplatelet agents. Anticoagulants inhibit thrombin generation and fibrin formation, and include vitamin K antagonists (warfarin), indirect thrombin inhibitors (unfractionated and low–molecular-weight heparins), direct thrombin inhibitors (dabigatran, argatroban, bivalirudin, and lepirudin) and factor Xa inhibitors (rivaroxaban, apixaban, edoxaban, and fondaparinux). Antiplatelet drugs block platelet activation and aggregation, and include aspirin and clopidogrel. Both classes of medications may increase a patient’s risk of intra- and postoperative bleeding, and should be noted prior to the procedure.^{57,58}

Table 36-3. Risk Factors for Increased Intraoperative Bleeding

Medications	Supplements	Genetic Diseases	Other Patient Factors
Aspirin	Ginseng	von Willebrand disease	Uremia
Clopidogrel	Ginkgo	Hemophilia A/B (factor VIII and IX deficiency)	Liver disease
Nonsteroidal anti-inflammatory drugs	Vitamin E	Other clotting factor deficiencies	Hepatosplenomegaly
Warfarin	Fish oil		Excessive alcohol use
Heparin	Garlic		Myeloproliferative diseases/ bone marrow failure
Dabigatran, Argatroban, Bivalirudin	Dong Quai (<i>Angelica sinensis</i>)		Vitamin K deficiency
Lepirudin	Feverfew		Immune thrombocytopenia
Rivaroxaban, Apixaban	Licorice		
Edoxaban, Fondaparinux	Bilberry		
	German chamomile		
	Red clover		
	Poplar		
	Meadowsweet		
	Willow bark		
	Tamarind		
	Danshen		
	Alfalfa		
	Goldenseal		
	Green tea		

Individuals on dual antithrombotic therapy are at the highest risk for procedure-related bleeding. A 2011 prospective study of 1911 patients demonstrated that patients taking both warfarin and clopidogrel had a 40 times greater risk of bleeding complications compared to other subjects.⁵⁹ In their retrospective study of 760 patients undergoing skin surgery, another group found a significantly higher rate of bleeding complications in patients taking two or more antithrombotic medications at the time of the procedure.⁶⁰ In addition to prescription medications, herbal supplements, including ginseng, ginkgo, vitamin E, fish oil, garlic, dong quai, and others, may potentiate bleeding risks.^{61–64} Inherited hemorrhagic disorders, including von Willebrand's disease, hemophilia, and clotting factor deficiencies, should also be identified prior to a dermatologic procedure. These inherited conditions should be managed in conjunction with the patient's hematologist, given the potential need for premedication or infusions prior to the procedure. Other patient comorbidities, such as uremia, liver disease, excessive alcohol consumption, vitamin K deficiency, immune thrombocytopenia, and bone marrow failure, may further impair thrombosis.⁷

For patients with increased bleeding risk, pertinent preoperative laboratory data such as prothrombin time (PT)/International Normalized Ratio (INR) and platelet count may be reviewed. Studies suggest that it is safe to proceed with dermatologic surgery if the INR is less than 3.5 within 1 week of the operation.^{65,66} A platelet count below 50,000 is widely considered a relative contraindication to an invasive procedure. It is recommended to discontinue elective ASA and/or NSAIDs 7 to 10 days before surgery.⁶⁶ In 2012, the American College of Chest Physicians recommended continuing warfarin or aspirin perioperatively and optimizing local hemostasis during minor dermatologic procedures.⁶⁷ The current consensus is that individuals should *not* stop any medically necessary anticoagulants or antiplatelet medications prior to dermatologic surgery, as the risk of catastrophic thrombotic complications exceeds the risk of bleeding.^{58,65} There may be instances in which reduction or cessation of anticoagulation is warranted. In such cases, the decision is best made on an individual basis, with active involvement of the prescribing provider.⁶⁸ A 2015 randomized, double-blind, placebo-controlled study demonstrated that, when patients with atrial fibrillation stopped warfarin therapy prior to an elective procedure, forgoing bridging anticoagulation with low-molecular-

weight heparin was noninferior to bridging for the prevention of arterial thromboembolism and resulted in a decreased risk of major bleeding.⁶⁹ This study indicates that there may be circumstances in which anticoagulation may be stopped without increased risk to the patient.

Consideration of closure type should also be made when operating on patients with an elevated bleeding risk. Of all closure types, flaps, grafts, and partial repairs have the highest risk of bleeding.⁵⁹ Undermining is important in surgical reconstruction, but should be performed only to the degree necessary to ensure adequate tissue movement. Wide and deep undermining can cause damage to large vessels and result in extensive dead space beneath the closure, thus increasing the risk of bleeding and hematoma formation.⁷ Drain placement may be appropriate in patients who have a large postoperative wound cavity and/or a baseline bleeding propensity. Drains may be passive or active; passive drains rely on gravity to evacuate fluid, while active drains are attached to a vacuum device. In dermatologic surgery, the drain used most frequently is a passive Penrose drain. The Penrose drain may exit a wound through the inferior aspect of the suture line or from a small opening near the incision. Active drains like Jackson–Pratt (JP) or Hemovac are closed systems that connect to a reservoir and have the advantage of removing bleeding through negative pressure. Drains should be removed within 24 to 48 hours to minimize the risk of infection (Fig. 36-2).



A





Figure 36-2. (A) Penrose drain placed in a large flap closure. This passive drain needs to be placed at the most inferior aspect of the wound. (B) Jackson–Pratt drain placed in a large flap closure.

Management of Uncontrolled Bleeding Intraoperatively

Direct pressure over a bleeding vessel for 15 to 20 minutes can tamponade active bleeding, thus allowing physiologic hemostasis to take place. This method is simple and effective, though it prolongs operative time and thus is infrequently utilized.⁷ In the postoperative period, pressure dressings at the surgical site left in place for 48 hours can reduce the risk of bleeding postprocedure.

Epinephrine is often added to local anesthetics. In addition to improving the duration of action of the anesthetic, epinephrine provides transient vasoconstriction. A recent triple-blinded, randomized control trial found that the time to maximal cutaneous vasoconstriction with lidocaine containing epinephrine 1:1000 is 25.9 minutes.⁷⁰ One caveat is that some patients may be excessively sensitive to the vasoconstrictive effects of the epinephrine, resulting in an intraoperative pseudo-hemostasis that manifests postoperatively with an increased risk of bleeding or hematoma formation. If this is suspected, meticulous hemostasis of all visible bleeding should take place.⁷

Suturing techniques may also aid in achieving hemostasis. Occasionally, transection of a larger vessel (>2 mm in diameter) leads to brisk bleeding not amenable to electrosurgery. Suture ligation offers a secure and long-lasting method of hemostasis for these vessels. After identifying the bleeding vessel, both ends of the transected vessel should be clamped with curved hemostats, and each end of the vessel can be directly ligated. Alternatively, in cases where the vessel cannot be directly sutured, a figure-of-eight suture or horizontal mattress suture may be placed around the bleeding area leading to compression and hemostasis.⁷

Topical hemostatic agents are also commonly used to control intraoperative bleeding. These may be categorized as physical hemostatic

agents, chemical hemostatic agents, biologic scaffold hemostatic agents, and biologically active hemostatic agents.⁷¹ Physical hemostatic agents function to tamponade blood vessels. Chemical hemostatic agents are caustic and lead to local tissue injury and subsequent thrombus formation. Biologic scaffold hemostatic agents provide a meshwork for platelet aggregation. Biologically active hemostatic agents are purified proteins in the coagulation pathway.⁷ These materials are listed in [Table 36-4](#). For intraoperative bleeding that will not respond to electrosurgery alone, the most frequently used topical agents are absorbable gelatin (Gelfoam®), oxidized cellulose (Surgicel®), bovine thrombin (Thrombin-JMI®), and recombinant thrombin (Recothrom®).

Table 36-4. Topical Hemostatic Agents

Agent	Mechanism of Action	Advantages	Disadvantages	Formulations	Notes
Physical hemostatic agents					
Bone wax (Beeswax)	Physical tamponade to bleeding	Easy to apply	Nonresorbable, development of foreign body granulomas	Paste	Most commonly used for bleeding vessels on the calvarium
Acrylates	Rapid Polymerization to block bleeding	Nonreactive	Moderately expensive, can adhere to mucous membranes	Solution	Acetone can dissolve excess. Often used for closure of small cutaneous surgical wounds
Chemical hemostatic agents					
Aluminum chloride	Protein precipitation, thrombus formation	No risk of tattoo, low cost	Tissue irritation	Solution	Flammable even without an alcohol base
Monsel's solution (ferric subsulfate)	Protein precipitation, thrombus formation	Skin or mucosal application, ease of use	Can lead to permanent tattooing effect, tissue reaction	Solution	May interfere with tissue staining in Mohs surgery
Zinc paste	Caustic agent, thrombus formation	Theoretical tumor destruction effect	Painful to apply, extensive tissue destruction	Paste	Used in early Mohs surgery tissue fixation <i>in vivo</i>
Silver nitrate	Silver ions bind and precipitate tissue proteins	Low cost, ease of use	Tattoo risk, theoretical risk of argyria with large area application	Solution	Commonly used to treat hypergranulation tissue
Biologic scaffold hemostatic agents					
Gelatin	Meshwork to promote clot formation	Nonreactive, resorbable, low cost	Infection risks, swelling can lead to nerve or vascular compression	Foam, powders	Can be combined with thrombin
Cellulose	Meshwork to promote clot formation	Low risk of infection, resorbable	Not for graft bed or near perichondrium	Mesh, gauze, sponge	
Microfibrillar collagen	Meshwork to promote clot formation	May be removed once hemostasis achieved	Easily adheres to wet surfaces, allergic reactions	Fibrils	Bovine source
Biologically active hemostatic agents					
Thrombin	Converts fibrinogen to fibrin	Nonreactive	Risk of disseminated intravascular coagulation if introduced to large-bore vessel; expensive	Solution, powder	Works best with biologic scaffold hemostatic agent
Fibrin glue	Direct coagulation	Nonreactive	Expensive	Solution	Prepared from patient's cryoprecipitate obtained from homologous donor, or synthetic

Electrosurgery is the most commonly used method of hemostasis in cutaneous surgery ([Chapter 16](#)). This leads to thermal damage, protein coagulation, and subsequent sealing of bleeding vessels. Electrosurgery includes electrodesiccation, electrofulguration, electrosection, and electrocoagulation. Another method of hemostasis, electrocautery, does not use electricity but rather direct heat to coagulate bleeding vessels. Electrosurgery and electrocautery are key components of dermatologic surgery, but, when used in excess, can result in delayed wound healing and poor cosmesis due to thermal tissue damage and injury to the surrounding lymphovascularity.⁷

Complications Associated With Electrosurgery

Cardiac Implantable Electronic Devices

In North America alone, there are more than 250,000 new cardiac devices implanted each year.⁷² As older patients are at higher risk for both skin cancers and cardiac conditions requiring implantable electronic devices (IEDs), understanding the potential implications of electrosurgery is prudent for the dermatologic surgeon.⁷³ Electromagnetic interference (EMI) from electrosurgical devices is relatively rare, as electrosurgery in office-based settings generates relatively low electromagnetic fields. In 2000, a survey of 166 Mohs surgeons revealed a low rate of complications due to electrosurgery (0.8 cases in 100 years of surgical practice) with no significant morbidity or mortality.⁷⁴ Complications included skipped beats (eight patients), reprogramming of a pacemaker (six patients), firing of an ICD (four patients), asystole (three patients), bradycardia (two patients), depleted battery life of a pacemaker (one patient), and an unspecified tachyarrhythmia (one patient). Bipolar forceps were not associated with any complications.

Cardiac pacemakers are electronic devices consisting of a pulse generator and leads which provide electrical stimulation to cause cardiac contraction if the intrinsic heart rhythm is absent or slowed.⁷⁵ In general, pacemaker patients are classified as *dependent* or *independent*. Pacemaker-dependent patients have inadequate or even absent intrinsic rhythm, and therefore can suffer significant symptoms or even cardiac arrest after cessation of pacing.⁷⁶ As a result, patients who are pacemaker dependent are at higher risk of complications from EMI during electrosurgery. Implanted cardioverter-defibrillators (ICDs) can detect and terminate life-threatening tachyarrhythmias via high-energy shocks, and pace bradyarrhythmias. If EMI is erroneously identified as a life-threatening arrhythmia, a shock may be delivered or the ICD may respond by inhibiting cardioversion or pacing.⁷⁷ ICDs are more sensitive to EMI than pacemakers. Additionally, with poorly grounded or nonisolated electrosurgery, an implantable cardiac device can work as an indifferent plate and cause myocardial burn or arrhythmia because the delivered energy is localized to a small area.⁷⁴ Safeguards against EMI are under continuous development and include insulated coatings to limit the distance current must flow between electrodes and

protective algorithms and filters that limit nonphysiologic interference.^{72,78} As a result of the protective circuitry of modern pacemakers, complications from EMI are currently quite rare.⁷²

As office-based monopolar electrosurgical units such as hyfrecators are low powered compared to their hospital operating room counterparts, a grounding pad is not consistently required.⁷⁸ Without a grounding pad, current disperses throughout the body and results in relatively safe means of obtaining hemostasis in most patients. However, since the current travels to a distant site, there is a potential risk of EMI with cardiac IEDs. In bipolar electrosurgery, current travels through a two-electrode instrument from one electrode, through tissue, to a second adjacent electrode, completing an electrical circuit. A grounding pad is not required and electrical energy capable of interfering with an IED is minimized.⁷⁸ A recent *in vitro* study observed that monopolar electrosurgical units did not interfere with defibrillators, and affected pacemakers only when used in close proximity to the device.⁷⁹ It was concluded that these devices are safe to use in patients with defibrillators at any distance and within 2 inches of pacemakers. However, conservative guidelines advise that electrosurgery should be avoided within 15 cm of a cardiac device without consultation from an electrophysiologist.⁷⁸ The safest forms of cautery in patients with cardiac IEDs are electrocautery (heat cautery) and electrosurgery with bipolar forceps (Fig. 36-3).



Figure 36-3. (A) Electrocautery and (B) bipolar forceps. These two methods of cautery are the safest in patients with implantable electrical cardiac devices.

A magnet placed over a pacemaker will switch most demand pacemakers to an asynchronous mode.^{72,80} In this mode, the heart is paced at a fixed rate regardless of the patient's underlying rhythm.⁷⁸ This method has been used to protect patients from the inhibition of the pacemaker by EMI. When the magnet is removed, the device should revert to previous programmed pacing.

Rare case reports of pacemaker malfunction have been associated with magnet use.^{35,77} For ICDs, tachycardia detection can be disabled by magnet application without having an effect on pace mode or rate. Most ICDs will revert to prior arrhythmia detection upon the removal of the magnet. An important feature unique to ICDs is that magnet response will not affect ICD antibradycardia pacing functions.⁸⁰ Unlike pacemakers, the pacemaker function of an ICD will not be rendered asynchronous. Thus, if a patient is dependent on the intrinsic antibradycardia pacing of their ICD, they will be potentially vulnerable to bradyarrhythmias from electrosurgery-induced EMI inhibiting the pacing function.⁸⁰ Surgeons should obtain direction from a cardiologist or the patient's pacemaker/ICD clinic prior to the use of magnets due to the low but potentially significant risks.

Noncardiac Implanted Electrical Devices

Noncardiac IEDs include deep brain stimulators, spinal cord stimulators, vagal and phrenic nerve stimulators, gastric stimulators, and cochlear implants. These IEDs can also develop complications related to EMI.⁷⁸ To limit the risk of EMI, many of these devices can be turned off with an external remote control. However, some devices cannot be inactivated due to functional or medical reasons. Electrosurgery can lead to electrode heating and tissue injury around the stimulator, as well as paresthesias and electrical shocks, even if the device is deactivated.⁷² As with cardiac devices, the risk is the greatest with monopolar electrosurgical devices. If a noncardiac IED cannot be deactivated, or the surgeon is working close to the electrodes, the physician managing the device should be consulted.

Burns and Fires

Approximately 50 to 100 surgical fires occur in the United States each year, with the majority involving either electrosurgery or laser devices.^{81,82} Of these cases, one to two per year result in death.^{82,83} In dermatology specifically, electrosurgical pencil tips for coagulation are a common ignition source.⁸² Dermatologists also routinely use flammable and combustible chemicals, such as surgical dressings, drapes, and certain cleansers (i.e., isopropyl alcohol).¹⁷ Petrolatum has not been found to be flammable and can be safely used in a surgical field.⁸⁴ Supplemental oxygen has been found to be a contributing factor in 74% of all surgical fires.⁸¹

Because 90% of surgical fires are caused by monopolar electrosurgical units and laser devices, bipolar electrosurgery is the preferred method of coagulation by the Emergency Care Research Institute as a means to prevent surgical fires in situations where oxygen supplementation is required.⁸¹ In the majority of dermatologic surgery procedures, patients' oxygen can be turned off while using electrosurgery without adverse effects. All surgical personnel should be trained in fire safety procedures, including initiating a "Code Red" and knowing the location of fire extinguishers and fire alarms.

Burns can also be a major complication secondary to electrosurgery.⁸² In one survey of otolaryngologists, 324 complications from electrosurgical instruments were reported out of 99,664 cases performed in 1 year. These complications included 219 unanticipated direct burns, 48 burns secondary to current flow through a metallic retractor or instrument, 13 grounding pad burns, and 11 fires.⁸⁵ Grounding pad burns typically occur due to a pad with dry gel, an improperly sized pad, moisture under the pad, or improperly positioning the pad. Single-use grounding pads should be placed on clean, dry skin overlying a well-perfused large muscle ipsilateral and close to the surgical site.⁸²

POSTOPERATIVE COMPLICATIONS

Pain

The majority of healthy patients who undergo MMS experience mild to moderate postprocedure pain.⁸⁶ A study of 433 MMS cases demonstrated that postoperative pain was the greatest on the day of surgery and associated most strongly with flap repairs, age less than 66 years, greater number of lesions treated, and the use of narcotics for pain relief.⁸⁷ Longer-lasting LAs, particularly 0.5% bupivacaine, can be injected into the surgical site to achieve extended postoperative anesthesia. Bupivacaine has an anesthesia onset of greater than 5 minutes and duration of 4 to 6 hours, compared to lidocaine, which works in less than 2 minutes and lasts 1 to 2 hours. It is important to note that bupivacaine injected without preanesthesia with lidocaine may be painful.⁸⁸ Nerve blocks can be utilized as an alternative, or, in addition to, infiltrative anesthesia for procedures on the face, hands, feet,

and digits. Nerve blocks have the benefit of decreasing tissue swelling/distortion, prolonging anesthesia, and reducing postoperative discomfort for the patient.³⁷ For a detailed discussion of nerve block options, see [Chapter 12](#).

Management of postoperative pain with analgesics is an important consideration in dermatologic surgery. Studies have shown that a preventive, single dose of acetaminophen ≤ 1 g, ibuprofen 400 mg, diclofenac 50 mg, or etoricoxib 120 mg immediately after surgery reduces postoperative pain and opioid use.^{89,90} Options for postoperative pain control include cold analgesia with ice or gel cold packs at the surgical site, acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs), opioids, or combination therapy.⁹¹ Acetaminophen remains the mainstay of pain management for minor dermatologic procedures. Doses of 500 mg to 1 g provide significant improvement in mild to moderate pain over 4 to 6 hours, up to a maximal daily dose of 3 g.⁹² At high doses of acetaminophen, rare side effects include liver failure and Stevens–Johnson syndrome. Because of risks of bleeding and hepatorenal syndrome, acetaminophen at a maximum daily dose of 2 g/day is the preferred analgesic in patients with advanced liver disease.⁹³ NSAIDs, such as ibuprofen, ketorolac, naproxen, celecoxib, and etoricoxib, are also commonly used to treat mild postoperative pain. Risks include impairment of renal perfusion, exacerbations of pre-existing renal dysfunction, weakening of gastric mucosa resulting in bleeding or perforation, worsening of underlying conditions such as hypertension, and induction of life-threatening hepatorenal syndrome in patients with cirrhosis.⁹¹

A common concern in dermatologic surgery is the effect of NSAIDs on hemostasis in the perioperative period. While it has been shown that NSAIDs do indeed increase bleeding time, the elevations are mostly within the normal range and last only hours.⁹⁴ A case series found that, in individuals taking aspirin or NSAIDs after cutaneous surgery, postoperative bleeding could not be attributed to either medication.⁹⁵ Research in the field of otolaryngology has demonstrated that the postoperative use of ibuprofen does not cause greater bleeding complications compared to acetaminophen.⁹⁶ Thus, the use of NSAIDs after dermatologic procedures likely confers a low risk for bleeding complications. A 2011 randomized controlled trial showed that the combination of acetaminophen 1000 mg and ibuprofen 400 mg offers

superior pain control compared with acetaminophen alone when given immediately postsurgery and every 4 hours thereafter for ≤ 4 doses after MMS.⁹⁷

Despite these favorable outcomes, some patients may still require opioid analgesics to control postoperative pain. Opioids are considered second-line therapy due to their adverse effect profile including nausea, constipation, and respiratory distress. Another potential risk of utilizing opioids for acute pain management is that regular use for as little as 1 week can result in dependence and withdrawal.⁹¹ Either manufactured or a-la-carte combination regimens including both an opioid (codeine, hydrocodone, or oxycodone) and nonopioid (acetaminophen, ibuprofen, or aspirin) analgesic are commonly used.

Hematoma

Hematomas are postoperative bleeding complications that occur if bleeding continues within a closed wound. Hematomas are problematic as they provide a substrate for bacterial growth leading to infections, prevent wound healing, and increase wound tension leading to possible dehiscence.⁶ Despite optimal perioperative patient management, meticulous surgical technique, and attentive hemostasis, hemorrhagic complications may still occur after dermatologic surgery procedures.⁹⁸ The risk of bleeding is the greatest in first 24 hours, and is most frequent in the first 6 hours.⁹⁹ If a hematoma is suspected, the patient should place immediate firm pressure with ice as a first step.⁹⁸ Any bleeding that does not resolve with pressure within 1 hour, or any rapidly expanding, painful subcutaneous mass should be evaluated on a more urgent basis.

Rapidly expanding hematomas indicate that there is an active bleed. They typically manifest as an enlarging, ecchymotic, fluctuant to firm mass with acute, throbbing pain (Fig. 36-4). For a rapidly expanding hematoma, the surgical closure must be partially or full opened, and the sources of bleeding identified and stopped.⁹⁹ Once hemostasis is obtained, the wound can be resutured. After postoperative bleeding is controlled, a pressure dressing should be left in place for a full 48 hours and placement of a drain may be considered.⁶



Figure 36-4. (A) Large hematoma of the cheek after rotation flap closure. (B) Stable late hematoma of the temple after primary closure.

Nonexpanding hematomas, or stable hematomas, also commonly develop within the first 48 hours. These hematomas tend to be small and do not compromise tissue viability. No immediate surgical intervention is necessary. Within 2 to 10 days, the hematoma tends to organize into a fibrotic clot, and after 14 days, the hematoma becomes fluctuant and eventually resorbs. Organized hematomas can be treated by incising with a #11 blade along the suture line or 1 cm away from the suture line, with subsequent expression of the contents. Fluctuant hematomas can be aspirated with a large-bore needle. For small hematomas, no intervention may be necessary,⁹⁹ although even small hematomas can contribute to delayed wound healing and tissue fibrosis.

Wound Dehiscence

Wound dehiscence is defined as separation of the epidermal and/or dermal edges of a wound (Fig. 36-5). The most vulnerable period for dehiscence is just after suture removal,⁹⁹ though wound dehiscence occurs in less than 1% of surgical cases. Anatomic location, but not type of closure, was

significantly associated with wound dehiscence (Fig. 36-6). Surgery on the chest, in particular, has a significantly increased risk of dehiscence when compared to other anatomic sites.⁵⁹ Causes of wound dehiscence include high wound tension, infection, necrosis, residual tumor, suture reaction, trauma to the wound, and poor wound healing secondary to anemia, hypoalbuminemia, diabetes mellitus, renal failure, and steroid use.



Figure 36-5. Wound dehiscence—epidermal and dermal separation of primary closure.



Figure 36-6. Dehiscence of wedge reconstruction on ear.

Whenever possible, wound dehiscence should aim to be prevented with proper surgical technique and detailed patient education. Removing wound tension through appropriate suturing techniques, closure design, and adequate undermining is key. Infections should be prevented and treated, and every effort should be made to remove residual tumor. The patient should be notified that the tensile strength of a surgical incision is only 10% at 2 weeks postoperatively.⁹⁹ Appropriate wound care instructions should be provided to the patient including the use of moist occlusion, gentle wound cleansing, and appropriate dressing material use. Patients should also be advised to limit certain activities or exercises that place undue tension on the wound.

The wound may be resutured in cases of early dehiscence due to premature suture removal or trauma without infection.⁹⁹ The surgeon should remove any devitalized tissue. The sutures should be removed and the wound explored if there is suspicion for hematoma. If the wound is infected or at a high risk for an infection, healing by second intention is preferred.

Skin Necrosis

Tissue ischemia is a result of decreased vascular perfusion that does not allow for adequate tissue perfusion. Ischemia can eventually result in tissue necrosis or death.⁹⁹ Black, densely adherent eschar represents tissue necrosis (Fig. 36-7).⁶ Skin necrosis is a rare complication seen in cutaneous surgery. Necrosis is often seen as a result of patient risk factors, anatomic risk factors, poor closure design (e.g., excessive tension), postoperative bleeding, or wound infection. Patient risk factors include anticoagulant use, hepatic or renal insufficiency, excessive alcohol consumption, and smoking (heavy smokers develop necrosis three times more frequently than never smokers).^{100,101} Tobacco use decreases cutaneous blood flow via nicotine (causes vasoconstriction) and carbon monoxide (impairs cutaneous oxygenation). It is recommended that patients decrease their smoking to <1 pack per day for 2 days prior to surgery and for 1 week postoperatively to minimize complications.⁶



Figure 36-7. (A) Impending necrosis of rotation flap. (B) Tissue necrosis of full-thickness skin graft. (C) Tissue necrosis of transposition flap.

Proper surgical technique also plays a major role in preventing ischemia and necrosis. Delicate tissue handling is important. The surgeon should aim to avoid macerating tissue edges; this can be achieved by using skin hooks or toothed forceps rather than serrated forceps.^{6,99} When undermining, the surgeon should avoid disrupting the dermal plexus by undermining at the appropriate depth.¹⁰² Strangulation of tissue with sutures can also lead to tissue ischemia. Elastic sutures may have a lower risk of necrosis because the suture material can expand with tissue edema.¹⁰³ The tip stitch, or half-buried mattress suture, minimizes compression on the subdermal vessels in order to minimize ischemic necrosis of vulnerable flap tips.¹⁰⁴ Mattress sutures, in contrast, may increase the risk of necrosis. Finally, prevention of hematoma, as noted above, may also prevent tissue ischemia and necrosis.

From the standpoint of closure design, high-tension closures should be avoided in order to minimize the risk of tissue ischemia.¹⁰⁵ Techniques to minimize closure tension include appropriate undermining, using plication sutures and/or dermal and subcutaneous sutures to decrease tension on the epidermal edge,¹⁰⁶ and using relaxation incisions or Z-plasties. Flaps and grafts have an increased risk of tissue ischemia compared to primary closures.¹⁰⁵ In flaps, the vascularity is based only on the pedicle supplying the tissue. The length of the pedicle correlates with the risk of flap necrosis. One study examining dermatologic surgery complications prospectively found that 4 of 241 patients (1.7%) of flap repair cases had evidence of partial flap necrosis; no complete flap necrosis occurred. The authors also found no significant association between anatomic site and flap necrosis. Graft necrosis tends to occur more frequently. In the same study, partial graft necrosis occurred in 13 of 152 patients (8.6%). Average graft loss was 50% of the total graft area.⁵⁹

The first signs of ischemia and necrosis may be seen intraoperatively. In the event of arterial insufficiency, the tissue tends to be dusky or pale and cool to the touch. If venous congestion is present, the tissue is typically dark purple and bleeds readily if pricked. In both of these settings, the surgeon should redesign or modify the closure to maximize blood flow. In the postoperative period, arterial ischemia can be reversed by early intervention, as the tissue is capable of surviving up to 13 hours. In venous congestion, the tissue progresses to necrosis much more rapidly. Serial pinpricks can be performed in the postoperative period to mitigate venous congestion. Postoperatively, tissue necrosis appears as a dusky eschar with tissue sloughing. Nonviable tissue should not be debrided given the risk of damaging underlying viable tissue. The wound should be kept moist and occluded, and patients should be counseled on the expected clinical course, including tissue sloughing and odor. Once the necrotic tissue has completely sloughed off, healing by second intention or surgical intervention can be considered. No surgical closure should be attempted with devitalized tissue still present in the wound bed.

Infection

Wounds can be classified (I to IV) according to the site and status of the wound preoperatively (Table 36-5).¹⁰⁷ While there are differing definitions of localized surgical skin infections, the Centers for Disease Control and Prevention states that a superficial surgical site infection (SSI) can be diagnosed if it involves skin, subcutaneous tissues, or muscle above the fascial layer at the incision site, occurs within 30 days of surgery, and at least one of the following is present:

Table 36-5. Wound Classification Based on 1985 Centers for Disease Control Classification of Wounds

Class	Skin Condition	Body Location/Surgical Technique	Antibacterial Recommendations
I	Clean	Sterile procedure	No prophylaxis
II	Clean contaminated	Oral cavity, nasal mucosa, perineum, axilla; sterile procedure	Prophylaxis only if immunocompromised
III	Contaminated	Traumatic wounds, nonpurulent inflammation; nonsterile procedure	Therapeutic antibacterials
IV	Infected	Gross contamination, devitalized tissue, foreign body contamination	Therapeutic antibacterials

- Purulent discharge from the incisional wound.
- Organisms are isolated on culture of aseptically obtained wound fluid or tissue.
- One or more of the following is present: pain, tenderness, localized swelling, redness, or heat.
- The surgeon deliberately reopens the wound (unless culture of the incision is negative)
- The treating doctor diagnoses a superficial incisional SSI.^{107–109}

The overall rate of infection is very low in dermatologic surgery, ranging from 0.7% to 3.5%.^{59,110,111} A wound infection develops when sufficient pathogenic bacteria contaminating the wound overcome the local tissue defenses and host response.¹¹² Postoperative surgical wound infections may have a significant effect on the outcome of a dermatologic surgical procedure, including the final cosmetic appearance of the wound.¹¹³ Higher risk procedures include those below the knee or in the groin area, wedge excisions of the lip and ear, flaps on the nose, and all skin grafts.^{107,111,112,114}

Intrinsic factors that place a patient at higher risk of infection include coincident remote site infections or colonization, cigarette smoking, diabetes,

systemic immunosuppression, obesity, extremes of age, and poor nutritional status.¹⁰⁷ The most common bacteria found in wound infections (in order of decreasing frequency) are *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Enterococcus* species, *Escherichia coli*, and *Pseudomonas aeruginosa*.¹⁰⁸ It is commonly thought that *P. aeruginosa* is the main pathogenic organism in infections of the ear after dermatologic surgery; however, it has been shown that *S. aureus* is actually the most common bacteria cultured from SSIs on the ear.¹¹⁵ *Enterococcus* and *E. coli*, as well as other gram-negative bacteria, are commonly cultured from groin and lower extremity infections.^{107,108} Most bacterial SSIs are a result of the presence of bacteria on the patients' skin or mucosa.¹¹⁶ Other potential sources of bacterial contamination include colonized surgical personnel, surgical suite fomites, adhesive dressings, and contaminated disinfectant solutions.¹¹⁷

Signs and symptoms of wound infection usually develop within 4 to 8 days postoperatively and are characterized by pain, erythema, tenderness, and purulent discharge (Fig. 36-8). Cellulitis occurs when the infection spreads into the surrounding skin and soft tissue beyond the incision and manifests as swelling, warmth, expanding redness, and pain. Infection is a clinical diagnosis based on the patient's signs and symptoms. Wound cultures may guide treatment, but a positive culture does not necessarily indicate active infection. Normal skin flora may be seen in wound cultures, and chronic wounds (>6 weeks) will almost universally be contaminated with bacteria.



Figure 36-8. (A) Superficial surgical site infection of primary closure on arm. (B) Surgical site infection of primary closure on the infra-auricular with underlying abscess. (C) Expressing pus from an abscess on the arm.

Severe Infections

Special considerations must be made when treating methicillin-resistant *S. aureus* (MRSA). MRSA can be hospital- or community-acquired; hospital-associated strains often exhibit multiple antibiotic resistance, while community-associated strains are often only resistant to methicillin.¹¹⁸ To diagnose MRSA, bacterial culture with antibiotic sensitivity should be obtained. MRSA should be suspected if SSI persists despite empiric antibiotic treatment. Treatment includes surgical drainage when an abscess is present and an appropriate antibiotic regimen consisting of either trimethoprim/sulfamethoxazole DS twice daily for 7 to 10 days, clindamycin 300 mg PO four times daily for 7 to 10 days, or doxycycline 100 mg twice daily for 7 to 10 days.¹¹⁷ Culture sensitivities and clinical response will subsequently determine whether alternative or additional antibiotic agents are necessary. The rates and antibiotic sensitivities of MRSA vary by region.

Necrotizing fasciitis occurs when pathogens extend beyond the skin and subcutis and involve the superficial fascia. The infection is usually polymicrobial, though *Streptococcus pyogenes* has been implicated in many cases.^{119,120} While early necrotizing fasciitis can be difficult to distinguish from cellulitis, red-flag symptoms include exquisite pain, violaceous bullae, eschar, necrosis, and decreased sensation.¹²¹ Necrotizing fasciitis is exceedingly rare following dermatologic surgery, but has been reported after excision of a melanoma.¹²² Inpatient management with surgical debridement, broad-spectrum antibiotics, and hemodynamic support is required.¹¹⁷

Very rarely, staphylococcal wound toxic shock syndrome can cause early fever and systemic signs following a surgical procedure.^{123,124} In these cases, the wound is often benign in appearance. Erythroderma tends to occur early with subsequent desquamation. Fever, hypotension, abnormal hepatic and renal blood studies, and diarrhea are early systemic findings. The incision should be opened and cultured, and the patient should begin antistaphylococcal treatment.¹²⁵

Infection Prevention. Many techniques exist to prevent infection in dermatologic surgery. Patient hygiene should be encouraged. Based on data from the general surgery literature, patients are often advised to shower before dermatologic surgery, despite a lack of data showing a clear benefit in cutaneous procedures.¹²⁶ A large systematic review recently illustrated no evidence of benefit for preoperative showering or bathing with chlorhexidine over other wash products.¹²⁷ If possible, surgery on areas of active infection or active inflammatory skin disease should be avoided. When it is necessary to remove hair, the existing evidence suggests that clippers are associated with fewer SSIs than shaving with razors.^{128,129}

Antiseptic agents are an initial line of defense against SSIs. The widely accepted technique for cleansing the skin prior to cutaneous surgery is to scrub with antiseptic in concentric expanding circles until a wide region is cleansed around the surgical site. This technique minimizes the chance of spreading pathogens from the periphery into the procedure site, and provides a sterile zone around the site where surgical instruments may contact without becoming contaminated.¹¹⁷

Commonly used surgical antiseptics include isopropyl alcohol 70%, povidone–iodine, and chlorhexidine gluconate with or without alcohol.

Isopropyl alcohol acts by denaturing microbial proteins and has a rapid onset. However, isopropyl alcohol is flammable and can irritate the skin.¹⁰⁸ Povidone–iodine acts through oxidation and substitution by free iodine. It has a broad spectrum of antimicrobial activity and a rapid onset of action, typically within minutes, but must be left on the skin to have sustained activity.¹⁰⁹ Povidone–iodine is inactivated by blood and sputum, can cause a contact allergy, and has been known to cause hypothyroidism in neonates when there is chronic maternal use.¹⁰⁸ Chlorhexidine gluconate disrupts cell membranes and has excellent gram-positive coverage and good gram-negative and viral coverage, but poor mycobacterial and fungal coverage.^{108,109} Chlorhexidine binds to the stratum corneum and maintains antimicrobial activity for longer than 6 hours even when wiped off. Chlorhexidine can cause keratitis and cochlear damage in the setting of a ruptured tympanic membrane, so the use around the eye and ears should be performed with caution.^{108,109}

Some research supports the efficacy of intraincisional antibiotics (nafcillin or clindamycin) to prevent postoperative wound infections when compared with placebo. The benefits of intraincisional antibiotic prophylaxis include immediate delivery to the surgical site, ease of use, enhanced compliance, and low cost compared with other routes of delivery.¹¹³ The limitations of this technique include the risk of patient allergy, and theoretically increased bacterial resistance. Postoperative topical antibiotic preparations have not been found to differ from petrolatum ointment in healing time or infection rate for clean surgical wounds.¹³⁰ Allergic contact dermatitis (ACD) is a well-documented adverse effect of topical antibacterial agents. For this reason, topical antibacterial preparations are not commonly indicated for routine use after dermatologic surgery procedures.

A few controversies exist in infection prevention techniques in dermatologic surgery. First, while many surgeons wear sterile gloves for dermatologic procedures such as excisions and MMS, a 2010 study suggested that clean, nonsterile technique is adequate for achieving an exceedingly low SSI rate.¹³¹ More recent studies also demonstrated no difference in infection rate when sterile versus nonsterile gloves are used during MMS resection and reconstruction, with the use of nonsterile gloves resulting in significant cost savings.^{132,133}

Second, a common practice is to use one sterile set of instruments for tumor removal and a different sterile set for the repair during MMS. One recent study suggested that using a single set of sterile surgical instruments for both removal and repair stages of MMS maintains SSI rates within an acceptable range and leads to cost savings.¹³⁴ However, further investigation is needed before this technique is broadly adopted, given concerns for SSI and potential issues of tumor spread from using a single set of instruments during MMS. Moreover, many clinicians use a minimalist instrument set for the performance of MMS (blade and forceps), while reconstructive surgical sets are generally much more involved. Thus, in practice, it is not clear whether this using the same instrument set would result in any significant cost or time savings.

Antibiotic Prophylaxis

Indiscriminant oral antibiotic prophylaxis is discouraged in cutaneous surgery, in light of the risk of possible adverse effects, antibiotic cost, and the potential for contributing to the development of antibiotic-resistant bacteria.¹⁰⁷ Antibiotics are associated with numerous adverse side effects ranging from mild gastrointestinal (GI) upset to serious cutaneous reactions such as toxic epidermal necrolysis, acute hepatitis, nephrotoxicity, and *Clostridium difficile* colitis.¹⁰⁸ Not only is the incidence of community acquired MRSA on the rise, but antimicrobial resistance to viridans group streptococci, one of the major causes of infective endocarditis (IE), is also increasingly reported in the literature.^{108,135}

An advisory statement published in 2008 provided an update on the indications for antibiotic prophylaxis in dermatologic surgery for the prevention of SSI, IE, and hematogenous total joint infection (HTJI).¹¹⁴ This statement incorporated recommendations from the 2007 American Heart Association (AHA) guidelines for endocarditis prophylaxis, as well as the 1997 and 2003 American Dental Association (ADA) and American Academy of Orthopaedic Surgeons (AAOS) advisory statements regarding prophylactic antibiotics in preventing HTJI following dental procedures.^{136–138}

If a dermatologic procedure involves the oral mucosa or infected skin (Class II), patients with certain cardiac conditions (Table 36-6) or joint

conditions should receive prophylactic antibiotics to prevent IE and HTJI, respectively. High-risk indications for HTJI include a history of total joint replacement within the preceding 2 years, previous prosthetic joint infections, and certain comorbidities with a history of joint replacement at any point in time.¹¹⁴ High-risk comorbidities include insulin-dependent (type I) diabetes, malignancy, immunosuppression, HIV, malnourishment, and hemophilia. Finally, antibacterial prophylaxis may be warranted for high-risk cardiac and whole joint prosthesis patients undergoing dermatologic surgery in sites that are associated with higher rates of infection (below the knee, in the groin, flaps on the ear and nose, wedge excisions, or grafts). These high-risk dermatologic surgery patients may also receive preoperative antibiotic prophylaxis to prevent SSI, but no guidelines exist delineating if and when this is warranted.¹⁰⁷

Table 36-6. Cardiac Conditions for Which Antibiotic Prophylaxis Is Recommended to Prevent Infective Endocarditis in Surgery Involving the Oral Mucosa or Infected Skin

Prosthetic cardiac valve or prosthetic material used for cardiac valve repair
Previous infective endocarditis
Congenital heart disease (CHD) from the following:
■ Unrepaired cyanotic CHD, including palliative shunts and conduits ■ Completely repaired congenital heart defect with prosthetic material or device, whether placed by surgery or by catheter intervention, during the first 6 months after the procedure ■ Repaired CHD with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device (which inhibit endothelialization)
Cardiac transplantation recipients who develop cardiac valvulopathy

A suggested antibiotic prophylaxis regimen for dermatologic surgical procedures that breach oral mucosa or involve infected skin of high-risk

patients is shown in Table 36-7.¹¹⁴ The same 2008 advisory statement suggested antibiotic prophylaxis regimens for patients at increased risk of SSIs (Table 36-8).¹¹⁴ Finally, in the setting of endocarditis prophylaxis, the AHA advises that an antibiotic should be given 60 minutes prior to a procedure, but may be given up to 2 hours after the procedure, if it is inadvertently not given before the procedure.¹³⁵ The ADA and AAOS recommended antibiotics to be administered 60 minutes prior to the procedure.¹¹⁴

Table 36-7. Suggested Antibiotic Prophylaxis Regimens for Dermatologic Surgical Procedures that Breach the Oral Mucosa or Involve Infected Skin in Patients at High Risk for Infective Endocarditis or Hematogenous Total Joint Infection

Surgical Site	Medication Restrictions	Agent	Adult Dose
Nonoral	No PCN allergy	Cephalexin	2 g PO
		OR Dicloxacillin	2 g PO
Nonoral	Patient with PCN allergy	Clindamycin	600 mg PO
		OR Azithromycin/clarithromycin	500 mg PO
Nonoral	Patient unable to take PO medication	Cefazolin/ceftriaxone	1 g IM/IV
Nonoral	Patient unable to take PO medication and has PCN allergy	Clindamycin	600 mg IM/IV
Nonoral (skin infected and pathogen known)	No PCN allergy	Antibiotic specific for pathogen	
Oral (breach of oral mucosa)	No PCN allergy	Amoxicillin	2 g PO
Oral	Patient has PCN allergy	Clindamycin	600 mg PO
		OR Azithromycin/clarithromycin	500 mg PO
Oral	Patient unable to take PO medication	Cefazolin/ceftriaxone	1 g IM/IV
		OR Ampicillin	2 g IM/IV
Oral	Patient unable to take PO medication and has PCN allergy	Clindamycin	600 mg IM/IV

IM, intramuscular; IV, intravenous; PO, by mouth; PCN, penicillin.

Table 36-8. Suggested Antibiotic Prophylaxis Regimens for Patients at Increased Risk of Surgical Site Infection

Surgical Site	Medication Restrictions	Agent	Adult Dose
Wedge excision of lip or ear; flaps on nose; all grafts	No PCN allergy	Cephalexin OR Dicloxacillin	2 g PO 2 g PO
Lesions in groin and lower extremities	No PCN allergy	Cephalexin OR TMP-SMX-DS OR Levofloxacin	2 g PO 1 tablet PO 500 mg PO
Wedge excision of lip or ear; flaps on nose; all grafts	Patient w/ PCN allergy	Clindamycin OR Azithromycin/clarithromycin	600 mg PO 500 mg PO
Lesions in groin and lower extremities	Patient w/ PCN allergy	TMP-SMX-DS OR Levofloxacin	1 tablet PO 500 mg PO
Wedge excision of lip or ear; flaps on nose; all grafts	Patient unable to take PO medications	Cefazolin/ceftriaxone	1 g IM/IV
Lesions in groin and lower extremities	Patient unable to take PO medications	Ceftriaxone	1–2 g IV
Wedge excision of lip or ear; flaps on nose; all grafts	Patient unable to take PO medications; has PCN allergy	Clindamycin	600 mg IM/IV
Lesions in groin and lower extremities	Patient unable to take PO medications; has PCN allergy	Clindamycin and gentamicin	600 mg/2 mg/kg IV

IM, intramuscular; IV, intravenous; PO, by mouth; PCN, penicillin; TMP-SMX-DS, trimethoprim-sulfamethoxazole, double strength.

Treatment

Once an SSI is diagnosed, wound culture should be obtained and the patient should be started on empiric antibiotics based on the most likely causal organism. A 7-day course of oral antibiotics is sufficient treatment for most SSIs. In the majority of cases, empiric treatment with an antibiotic that has activity against *S. aureus* is effective. This treatment includes either a first-generation cephalosporin, such as cephalexin 250 to 500 mg PO three or four times daily, or a penicillinase-resistant penicillin, such as dicloxacillin 250 to 500 mg PO twice, three or four times daily.¹¹⁷ Antibiotic therapy should be modified, if necessary, based on culture and sensitivity results. If an abscess is present, it should be drained in a sterile setting under LA. Some or all sutures may need to be removed to permit adequate drainage. The wound then may either be packed with sterile gauze or allowed to remain open to drain. The patient should be seen for close follow-up to ensure resolution of the infection and to monitor for future complications.

Nerve Damage

Sensory Nerves

Cutaneous nerves are commonly transected during dermatologic surgery. As a result, patients frequently experience paresthesias at the procedure site. Given that most areas on the skin have diffuse sensory innervation, and

sensory nerves often regenerate, there are rarely significant permanent deficits from cutaneous surgery. Patients should be counseled preoperatively about risk of paresthesias at the surgical site, and that normal sensation usually returns within 18 months. Occasionally, complete sensation never returns. Areas most prone to sensory nerve injury and appreciable deficits are the digits, forehead, and scalp. In particular, procedures that require deep tissue removal or dissection risk permanent damage to the branches of the trigeminal nerve on the face, with subsequent sensory loss.

Motor Nerves

Injury to motor nerves can result in more severe consequences than damage to sensory nerves. Though rare, damage to motor nerves can cause significant functional impairment. While many of the muscles of the head and neck have significant redundancy in innervation, there are specific motor nerve “danger zones” that are most at risk during dermatologic surgery. Overall, the risk of motor nerve damage in dermatologic surgery is very low, but patients need to be counseled preoperatively when operating in high-risk locations. Surgeons also need to be aware that significant individual variability exists in the anatomic course of nerves. Additionally, patients with tissue atrophy, such as seen with normal aging or HIV lipoatrophy, will have motor nerves coursing in a more superficial plane. If motor nerve damage occurs, it may be temporary (neuropraxia) or permanent. It is prudent to consult with the appropriate specialty (generally neurology or otolaryngology) early to optimize management after motor nerve damage. The nerves at the greatest risk for injury during cutaneous surgery are the temporal and marginal mandibular branches of the facial nerve and the spinal accessory nerve.⁴⁴

The temporal branch of the facial nerve is the most commonly injured nerve in facial surgery. When damaged, it will lead to ipsilateral brow ptosis secondary to paralysis of the frontalis muscle (Fig. 36-9).¹³⁹ The nerve branches off the facial nerve trunk within the parotid gland and courses superficially across the zygomatic arch within the innominate fascia (a plane deep to the SMAS and superficial temporal fascia), and crosses the temple with little overlying subcutaneous fat.¹⁴⁰ If nerve damage is permanent, this complication can be addressed with a direct or indirect brow lift. Over time, patients may develop a compensatory brow elevation on the contralateral side of injury.¹³⁹



Figure 36-9. Injury to the temporal branch of the facial nerve resulting in the inability to raise the right brow due to frontalis muscle paralysis.

The marginal mandibular branch of the facial nerve traverses the mandible near the facial artery and vein, covered only by skin and thin platysma muscle. While the nerve is normally located approximately 1 to 2 cm below the mandible, in individuals with lax or atrophic tissues (as seen with aging), the branches can be as low as 3 to 4 cm below the mandible.¹⁴¹ This nerve innervates the lip depressors, and damage presents clinically as asymmetric facial expressions and mouth function compromise. This asymmetry and lip imbalance are readily noticeable during opening of the mouth (Fig. 36-10).¹⁴² The marginal mandibular nerve is at risk during liposuction of the jowls and neck dissections, as well as after deoxycholic acid injections for submental fat.^{143,144} The buccal and zygomatic branches are deeper, with more collateral innervation, and are at less risk of damage when compared to the other branches of the facial nerve.



A



B

Figure 36-10. Marginal mandibular nerve paralysis after neck dissection, with injury on the right side: (A) At rest; (B) smiling showing compensation on the left side.

Finally, damage to the spinal accessory nerve results in a winged scapula due to trapezius muscle palsy. This palsy results in dropping of the shoulder

girdle inferiorly and laterally along with flaring of the wing of the scapula and loss of abduction of the arm.⁴⁴ The spinal accessory nerve exits behind the sternocleidomastoid (SCM) muscle at the junction of the upper and middle third of the SCM, then courses across the posterior triangle of the neck. It primarily innervates the trapezius and partially innervates the SCM. Inadvertent transection can occur during procedures in the posterior triangle of the neck, including radical neck dissection, lymph node dissection, and extensive cyst or tumor resection.

Suture Reaction

All sutures elicit some degree inflammatory response when embedded in tissue, but the response is variable. Several factors contribute to tissue reactivity including suture material, configuration, caliber, and absorbability. The degree of inflammatory response to biologic sutures (i.e., fast, chromic, or plain gut or silk) is much higher than that seen with synthetic sutures (i.e., nylon or polypropylene).¹⁴⁵ Additionally, monofilament configurations of suture are thought to lead to less reactivity when compared to a multifilament configuration. Immediate postoperative suture reaction is characterized by erythema and tenderness of the skin. When suture reaction develops later in the postoperative course, it often presents as a “spitting suture,” where there is residual suture material in the skin and/or an inflammatory foreign body reaction (Fig. 36-11). Spitting sutures tend to occur 1 to 4 months postoperatively and present as a focal, aseptic pustule at the site of a buried suture. One study examined 140 patients and found that suture reaction was significantly less with poliglecaprone-25 (3.1%) as compared to polyglactin-910 (11.4%).¹⁴⁶ Surgical techniques that can help prevent spitting sutures include placing absorbable sutures deep in the dermis, utilizing the set-back suture technique, cutting sutures at the knot, and closing wounds with minimal tension.^{146–148} To treat a spitting suture, the site can be nicked with an #11 blade and the purulence expressed and residual suture removed.



Figure 36-11. (A) Immediate suture reaction presenting as erythema and edema at 1 week postoperative. (B) Late suture reaction to deep sutures presenting as sterile pustules along the closure line at 6 weeks postoperative. (C) Late suture reaction presenting as small ulceration along suture line.

Contact Dermatitis

ACD represents a type IV hypersensitivity reaction, and ranges in presentation from mildly pruritic erythema to intensely pruritic vesicular, bullous, or indurated plaques. The presence of erythema and induration around a postoperative surgical site may initially raise concern for SSI, but the clinical appearance of a contact dermatitis differs from infection. Contact dermatitis often occurs away from the wound edges, may have an angulated appearance, lacks purulence and tenderness, and is frequently itchy (Fig. 36-12). ACD may be caused by any material in dermatologic surgery, including surgical antiseptics and wound dressings. Antiseptics used to prepare the surgical site are common causes of contact dermatitis. Most commonly, this is seen with povidone–iodine, but a similar reaction has also been reported to chlorhexidine.¹⁴⁹ Postoperatively, fixatives (e.g., benzoin and mastisol), dressings (e.g., colophony), and antibiotics (e.g., bacitracin and neomycin) are potential sources of ACD. If a patient has a history of ACD, it is

recommended that white petrolatum be used instead of any potential allergy-inducing products.¹⁴⁹ Contact dermatitis will frequently resolve spontaneously once the implicated agent is removed from the skin. However, in cases of severe reactions that present with blistering or severe pruritus, topical or even systemic steroids may be helpful.

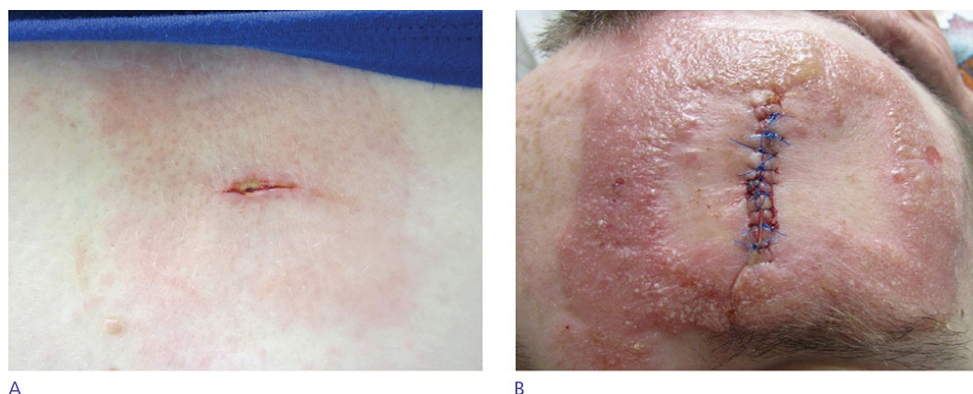


Figure 36-12. Contact dermatitis presenting as angulated erythema corresponding to the location of adhesives. (A) Mild erythema and itching. (B) Severe reaction with blisters and edema.

Abnormal Wound Healing and Scarring

Excessive Granulation Tissue

Excessive granulation tissue is considered a type of abnormal wound healing and is often seen in wound healing by second intention.¹⁵⁰ Associated factors include wound site, prolonged inflammation, an imbalance in matrix metalloproteinases, and excessive angiogenesis. While a modest amount of granulation tissue is considered favorable in wound healing by second intention, too much granulation tissue inhibits wound healing by preventing fibroblast proliferation. Granulation tissue appears beefy red and friable, and may extend above the level of normal skin. Management of excessive granulation tissue includes destruction with silver nitrate, laser ablation, cautery, curettage, or shave removal of the tissue. Medium- to high-potency topical corticosteroids have also been used with success.^{150,151}

Scarring

Scarring after skin cancer surgery can profoundly affect psychosocial functioning, especially when scars are located on the head and neck.¹⁵² For

many patients, the success of a surgical procedure is often tied to the aesthetic appearance of the final scar. Surgical scars tend to have a variable presentation, and may have multiple features that must be addressed for optimal scar reduction. Scars may be characterized by abnormal erythema or pigmentation, firmness, visibility, contour irregularity, and other negative factors. Additionally, the position, location, age of the scar, and skin type of the patient should be considered. For many surgical scars, time will resolve many of the adverse features. Laser therapy with multiple different energy modalities has been shown to improve scar features.^{153,154} Dermabrasion is another method for treating surgical scars, and is particularly useful on sebaceous nasal skin.¹⁵⁵ Surgical scar revision may be attempted if the scar is not exhibiting favorable characteristics for long term. Multiple techniques may be utilized, including scar excision with linear closure, Z-plasty, W-plasty, and geometric broken line closure.¹⁵⁵ Surgical scar revision techniques are addressed in detail in [Chapter 35](#).

Hypertrophic/Keloid Scars. Hypertrophic scars and keloids are two forms of abnormal wound healing characterized by local fibroblast proliferation and excessive collagen production in response to cutaneous injury. Hypertrophic scars tend to remain confined to the scar line, whereas keloids extend beyond the margin of the scar. Hypertrophic scars often arise earlier than keloids, usually within 4 weeks postoperatively. Keloids may develop months to a year after trauma or surgery.¹⁵⁶ Hypertrophic scars can regress without intervention, whereas keloids do not, and indeed frequently recur after surgical removal. Keloids are more common on the chest and back of darker-skinned patients, and are often also seen at the sites of wounds healing by second intention.¹⁵⁷ In contrast, spread scars tend to be more atrophic, with thin, fragile tissue centrally. Spread scars occur in areas under high tension, high use (shoulders, chest, back), and in the context of infection or dehiscence.

The first-line treatment for hypertrophic scars and keloids is intralesional steroid injections.¹⁵⁸ While this approach is considered largely effective, it may be associated with cutaneous atrophy, pigmentary alteration, and telangiectasias.¹⁵⁹ Re-excision with the addition of pressure therapy, postoperative radiation, and intralesional steroid injections has also been performed with success for keloids,^{160,161} and one study has demonstrated an effective combination of re-excision and closure with the set-back suture

coupled with postoperative radiation.¹⁶² Finally, silicone gel sheeting, 585- or 595-nm pulsed-dye laser, cryotherapy, intralesional 5-fluorouracil (5-FU), interferon alfa-2b injections, fractional nonablative lasers, and ablative laser treatment may also be of benefit for keloids.^{163–168}

Suture Track Marks. Track marks are often seen when epidermal sutures are left in place longer than necessary or are placed too tightly (Fig. 36-13).¹⁰⁴ Postoperative edema tends to exacerbate track marks due to increased tension on epidermal sutures. To prevent track marks, sutures should be removed as early as possible, wound tension should be maximally decreased by performing adequate undermining, buried dermal or subcutaneous sutures should be used for tension reduction, and sutures of appropriate size should be used for a given anatomic location. A recent randomized controlled trial found the set-back suture to be superior to the buried vertical mattress suture for postoperative scar cosmesis.¹⁴⁸ Tissue adhesives or adhesive strips may also be used in place of epidermal sutures in order to prevent track marks as long as dermal sutures have been placed to reduce tension.¹⁶⁹



Figure 36-13. Spread surgical scar.

Trapdoor Phenomenon

The trapdoor phenomenon, or pin-cushioning, is a contour irregularity due to scar elevation above the surrounding skin surface. This abnormal scarring is most frequently seen in flaps on the nose and upper cutaneous lip ([Fig. 36-14](#)). Irregular flap contour may be due to several factors, including lymphatic or venous obstruction, postoperative ischemia, resolving hematoma, scar hypertrophy, excessive subcutaneous fat or flap tissue, and scar contracture. The deformity typically appears within 3 weeks to 6 months after surgery and can be prevented with optimal flap design, wide undermining of the recipient site, squaring of the corners (versus circular trimming), appropriately thinning the flap, and the judicious use of dermal sutures to re-approximate muscle and dermis. Potential treatments include surgical revision by lifting and thinning of the flap, intralesional steroid injection, and dermabrasion. Over time, improvement may be seen without intervention. [170,171](#)



Figure 36-14. Pin-cushioning or trapdoor deformity of transposition flap on the nose.

Free Margin Retraction

Free margins are anatomic areas where the skin surface remains unattached to the surrounding tissue. Common free margins on the face are the eyelid, helical rim of the ear, alar rim of the nose, and the vermilion lip. Because they offer little resistance to tension created by surgical reconstruction or scar contracture, free margins are vulnerable to distortion ([Fig. 36-15](#)).



A



B

Figure 36-15. Contracture of a free margin resulting in (A) ectropion after lower blepharoplasty and (B) alar retraction after interpolated flap necrosis.

Disruption of these natural contours is both aesthetically displeasing and functionally significant. Ectropion may result in difficulty closing the eyelids with subsequent dry eyes and corneal irritation, alar rim retraction can cause

nasal valve obstruction, and eclabium can lead to challenges when creating a tight oral seal.

To prevent these complications, surgical closures must be designed to minimize tension on the free margin; this is often achieved by orienting closure tension vectors perpendicular to the free margins to avoid “pulling” the free margin out of position.¹⁷² Cartilage grafts may be used to prevent alar rim retraction, and Frost sutures may be used to prevent ectropion in the immediate postoperative period, though they cannot compensate for poorly designed closures.¹⁷³ Caution should be used when using second-intention healing or when placing skin grafts in locations near a free margin, as clinically significant contraction may occur. Treatment of free margin retraction includes intralesional steroids and scar revision.

SEVERE POSTOPERATIVE RISKS OF DERMATOLOGIC SURGERY

The incidence of catastrophic complications in dermatologic surgery is exceedingly low, but providers should be aware of potential emergent situations so that early detection may mitigate adverse outcomes. Such emergent scenarios include anaphylaxis from type I immune hypersensitivity reactions, cardiac arrhythmias from electrosurgery, and local anesthetic/lidocaine toxicity.⁴⁴

Life-threatening air embolism resulting from the removal of large scalp tumors has been reported in the dermatologic surgery literature.^{174,175} Positioning the patient flat during surgery, so as to minimize a pressure gradient, and using airtight dressings between MMS stages helps to prevent this complication.⁴³ If faced with a potential air embolism, the dermatologic surgeon should immediately refer the patient to a higher level of care, due to the risk of permanent neurologic insult.

Venous thromboembolism—including deep vein thrombosis and pulmonary embolism—is another reported complication after MMS.^{176,177} Most cases of DVT and PE after dermatologic surgery have occurred in patients with underlying hypercoagulability who have discontinued anticoagulation perioperatively. Treatment includes anticoagulation, inferior vena cava filters, thrombolysis, and compression stockings.⁴³

RISKS TO THE DERMATOLOGIC SURGEON AND OTHER HEALTH CARE PERSONNEL

Surgical Smoke

Surgical smoke or plume is the gaseous byproduct produced by the destruction of human tissue by electrosurgery or other procedures.¹⁷⁸ It is estimated that a Mohs surgeon who performs 1000 cases per year receives approximately 50 hours of continuous smoke exposure per year.¹⁷⁹ Surgical smoke and plume generated by electrosurgery and lasers have been demonstrated to harbor live viruses and bacteria in addition to hazardous chemicals. As a result, the potential exists for infection, carcinogenesis, and pulmonary damage from surgical smoke exposure.¹⁸⁰ Surgeons' exposure to smoke is more concentrated than for other perioperative personnel because they are closest to the tissue destruction. The use of standard surgical masks offers little to no protection against inhalation of surgical smoke. The best protection for surgical personnel is the use of smoke evacuator units during electrosurgery. Integrated cautery and smoke evacuator units are convenient and easy to use, decrease the need for extra staff, and improve patient comfort by aiding in the removal of unpleasant odor of surgical smoke.

Sharps Injuries

The CDC estimates that more than 380,000 sharps exposures occur annually.¹⁸¹ Sharps injuries pose an occupational hazard to dermatologists because of the large number of procedures they perform. A 2013 cross-sectional survey of practicing dermatologists and trainees revealed that 85.1% of 336 responders had experienced a needle stick injury during their career. Importantly, 64% of respondents experienced a sharps injury that they did not report.¹⁸² The most frequently cited reason for not reporting an injury was the belief that the patient was a low risk for a hematologically spread infectious disease. A similar 2016 survey of dermatology residents showed that, of 351 responders, 76% had a sharps injury during training and 34% went unreported.¹⁸³ Given the risk of communicable diseases such as hepatitis B virus (HBV), hepatitis C virus (HCV), and human

immunodeficiency virus (HIV), it is important to promptly report injuries to occupational health services so that appropriate baseline and follow-up testing can be informed, and prophylactic medication administered. Improving the ease of access to reporting systems, ensuring anonymity, and encouraging ongoing sharps safety training may increase the prevalence of reporting.¹⁸² In addition, continued efforts to decrease the stigma associated with medical errors are essential.

To prevent sharps injuries in dermatologic surgeons and other team members, several preoperative, intraoperative, and postoperative techniques can be employed.¹⁸⁴ Preoperatively, one should wear protective devices (gloves, masks, protective eyewear, and protective footwear). Intraoperatively, it is important to practice safe handling and transferring of sharp instruments, minimize the use of sharps, and protect from backsplash injuries. When treating patients with known infectious hepatitis or HIV, the use of blunt skin hooks, safety scalpels, safety syringes, smoke evacuators, a separate ink supply during MMS, or 24-hour formalin fixation resulted in no exposures in 188 surveyed Mohs surgeons.¹⁸⁵ Postoperative measures that should be taken include the proper disposal of used sharps.

CONCLUSIONS

Dermatologists perform almost 10 million procedures annually; even in this context, the rate of surgical complications is very low, and the rate of serious surgical complications remains vanishingly rare. Adhering to standard safety recommendations may increase the level of safety for dermatologic surgeons and their patients, and developing protocols for management of surgical complications may help mitigate the severity of these problems when they arise. Critically, patients must be educated preoperatively regarding the risks associated with a given procedure, as managing patient expectations regarding the baseline risk of undesirable outcomes may help foster a team approach to care and management.

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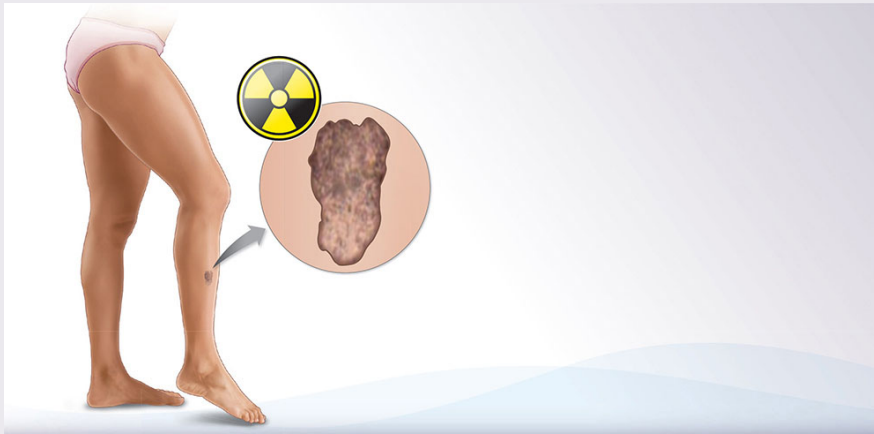
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CHAPTER 37 Superficial Radiation Therapy and Electronic Brachytherapy

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Jonathan Chan



SUMMARY

- Superficial radiation therapy (SRT) relies on low-energy photon radiation.

- SRT is a viable nonsurgical option for the treatment of select nonaggressive primary BCCs and SCCs in patients where surgical intervention is refused or inadvisable.
- An understanding of basic radiobiology is a prerequisite for utilizing any form of radiation therapy.

Beginner Tips



- The time–dose–fractionation (TDF) table provides a choice of protocols for a course of SRT based on the total dose of radiation, number of fractions, and duration of treatment.
- Hyperfractionated dosing regimens may yield an improved outcome.
- Ideally, radiation treatment for keloids should be administered within 2 days of surgical excision.

Expert Tips



- Various fractionation protocols may be used to accommodate the needs of each patient based on the size and location of the tumor, vascularity of the tissue, and the sensitivity of the tumor to radiation.

- Protocol modifications may include reducing the fraction size, increasing the number of fractions and total radiation dose, and changing the overall duration of treatment from the first fraction to the last.
- Modifying the size and number of the fractions and the total dose of administered radiation can prevent or minimize the occurrence of acute and latent radiation reactions while still optimizing the cure rate.

Don't Forget!



- While there is no immediate scarring from SRT, significant long-term scarring is possible, especially over time.
- Importantly, none of the recent SRT studies had a mean duration of follow-up greater than 5 years; therefore, long-term results should be viewed with caution.

Pitfalls and Cautions



- Acute reactions are defined as adverse events occurring within 90 days of administration of the first dose fraction.
- Latent reactions are defined as reactions occurring more than 90 days following the administration of the first fraction.

- Dyspigmentation and telangiectasias are seen frequently, and unlike surgical scars, which tend to improve over time, long-term sequelae of SRT tend to worsen over years and decades.

Patient Education Points



- While there is no surgical scar after SRT, it is *not* a scar-free procedure, and dyspigmentation, textural changes, and telangiectasias tend to increase over time.
- Therefore, this approach should be used with extreme caution in younger patients.

Billing Pearls



- Each SRT treatment should be billed using CPT code 77401. This code should only be used as a single unit, regardless of the number of areas treated per day.

CHAPTER 37 Superficial Radiation Therapy and Electronic Brachytherapy

INTRODUCTION

Superficial radiation therapy (SRT) uses low-energy photon radiation that minimizes penetration beyond the thickness of the skin.¹ Half of the energy is absorbed within the superficial layers of skin. On the electromagnetic spectrum, SRT waves are just above Grenz rays, low-energy or “ultrasoft” x-rays produced by 10 to 30 kV x-ray machines. Grenz rays have a half-value depth of 0.5 mm and are absorbed within the first 2 mm of skin tissue. Historically, there are numerous uses for SRT, though the primary use of the technology has been the treatment of nonmelanoma skin cancers (NMSCs) and the prevention of keloid scar recurrence.²

Among the numerous available methods for treating NMSC, SRT is an alternative treatment used by office-based dermatologists. In contrast with penetrating forms of radiation, such as electron beam radiation, SRT deposits 100% of its energy at the surface layer of the skin. With proper dosimetry and fractionation, it avoids deep tissue damage and causes minimal scarring. SRT results in acceptable cure rates for primary nonaggressive basal cell carcinoma (BCC) and squamous cell carcinoma (SCC) and a relatively low incidence of complications. It does not require that patients stop receiving

anticoagulants, and can be utilized safely in patients with poor circulation and contraindications for surgery. While the use of SRT steadily decreased during the past several decades, the recent availability of newer equipment and treatment strategies has led to a resurgence of SRT use for treating NMSC.

SRT is well suited for treating many anatomical areas.^{3–9} Most skin cancers occur on the scalp, forehead, eyelids, ears, nose, lips, cheek and chin, where surgical removal of large tumors may require reconstructive surgery.¹⁰ SRT may be beneficial for NMSC on the lower extremities, especially in elderly patients with background stasis dermatitis, chronic edema, or circulatory compromise.

There is no treatment-related discomfort associated with the use of SRT, making it ideal for patients that fear surgery or those with contraindications to surgical intervention.¹¹ Among patients with BCC, SRT improves quality of life despite the occasional occurrence of skin atrophy, dyspigmentation, alopecia, and telangiectasia.¹²

NONMELANOMA SKIN CANCER

In 2012, the National Cancer Institute estimated that 81,240 people (46,890 men and 34,350 women) would be diagnosed with BCCs and SCCs and that 12,190 people would die because of NMSCs.¹³ Based on the number of cases diagnosed in 2005 to 2009, the annual age-adjusted incidence of skin cancer is 23.0 per 100,000 men and women. The incidence among white patients is higher, with an incidence of 34.5 per 100,000 men and 21.3 per 100,000 women;¹³ however, the real incidence of skin cancer is considerably higher, as NMSC is excluded from most cancer registries. Based on a large US commercial insurance claims database, the actual incidence has been determined to be 693 per 100,000 persons or approximately 2,139,535 cases in the United States (0.7% of population).¹⁴ A study from South Florida estimated the annual incidence of NMSC to be 466.5 per 100,000 persons less than 65 years of age and 10,690 per 100,000 persons 65 years of age and older.¹⁵

Current evidence suggests that the incidence of skin cancer continues to increase from 1996 to 2008, the total number of skin cancer treatment

procedures increased by 53% from 1,480,645 to 2,152,615.¹⁶

Figures 37-1 through 37-4 demonstrate the use of SRT for the treatment of BCCs and SCCs in various patients. Figure 37-5 demonstrates the use of SRT for the treatment of an ear keloid.



Figure 37-1. Treatment of a nodular basal cell carcinoma of the nose with superficial radiation. This patient is a 73-year-old woman with a history of prior skin cancers and a biopsy-confirmed nodular basal cell on her right ala. After a discussion of the available treatment options, she elected to undergo treatment with SRT. The 5×6 mm lesion was circled with a 5-mm border and a 1.7-cm shield was fashioned out of 0.762-mm-thick lead and placed over the site in addition to intranasal and thyroid shielding. The patient received 500 cGy at 50 kV, 10 MA, the treatment time was .64 minutes with a TSD of 15 cm and zero filtration. The patient returned six more times over the next 3 weeks, receiving a total of 3500 cGy. The patient returned 14 days later and was pleased with the results. There was no recurrence after 4 years. Nodular basal cell carcinoma of the nose. (A) The 5×6 mm lesion was circled with a 5-mm border prior to treatment. Seven fractions of 500 cGy were delivered at 50 kV and 10 mA with a $D_{1/2}$ of 5.8 mm. (B) Posttreatment day 14. (C) There was no recurrence after 4 years.

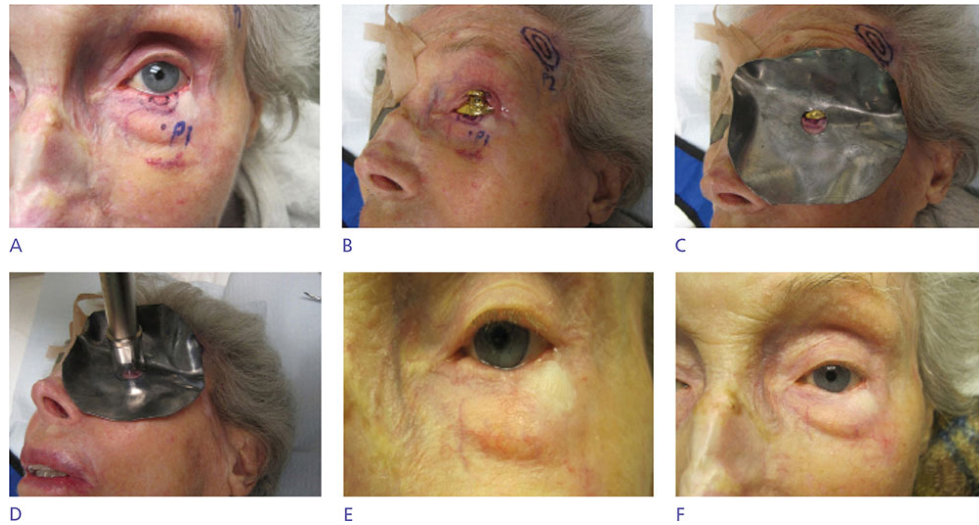


Figure 37-2. Treatment of an in situ large squamous cell carcinoma of the eyelid with superficial radiation. The patient was a 93-year-old woman with a history of numerous difficult skin cancers on her face for which she had undergone multiple Mohs surgeries and skin grafts and flaps. She presented with a crusted lesion on her left lower eyelid. The lesion is near (medial) to a Mohs site repaired with a full-thickness skin graft for squamous cell carcinoma in situ 2 years earlier. This lesion was biopsied and found to be an actinic keratosis/squamous cell carcinoma in situ. Since the patient had undergone Mohs surgery of the left lower eyelid with full-thickness skin graft 2 years prior, Mohs surgery on this lesion could potentially worsen her existing slight ectropion. After discussing the use of Mohs surgery or SRT to treat this lesion, the patient chose SRT. The clinical lesion was identified and circled and a 5-mm border was drawn around this. A 0.762-mm-thick lead shield was custom made to include a 1.3-cm field and placed over the lesion and extended field. The patient was placed on the x-ray table in the supine position. One drop of tetracaine solution was instilled into her left eye and after 2 minutes, a lubricated gold-plated lead shield was placed inside the eyelid of the left eye. This was covered with the custom lead shield, while the right eye was covered with a standard lead eye shield and the thyroid was also covered with a lead shield. Using a 1.5-cm cone, seven fractions of 498.6 cGy (3490.2 cGy total) were delivered at 50 kV and 10 mA with a $D_{1/2}$ of 5.8 mm over a 3-week period which yields a TDF of 92. The patient tolerated SRT well and without complaints during the treatment regimen. She has no complaints of dry eye, or more than her usual amount of eye weeping. (A) The lesion was identified and circled, and a 5-mm border was drawn around this. (B) Two minutes after tetracaine solution was instilled into the left eye, a lubricated gold-plated lead shield was placed inside the eyelid of the left eye. (C) A custom 0.762-mm-thick lead shield was custom made to include a 1.3-cm field and placed over the lesion and extended field. (D) Using a 1.5-cm cone, seven fractions of 498.6 cGy (3490.2 cGy total) were delivered at 50 kV and 10 mA with a $D_{1/2}$ of 5.8 mm over a 3-week period which yields a TDF of 92. (E) Appearance of the eyelid 72 days posttreatment. (F) There was no recurrence after 15 months.

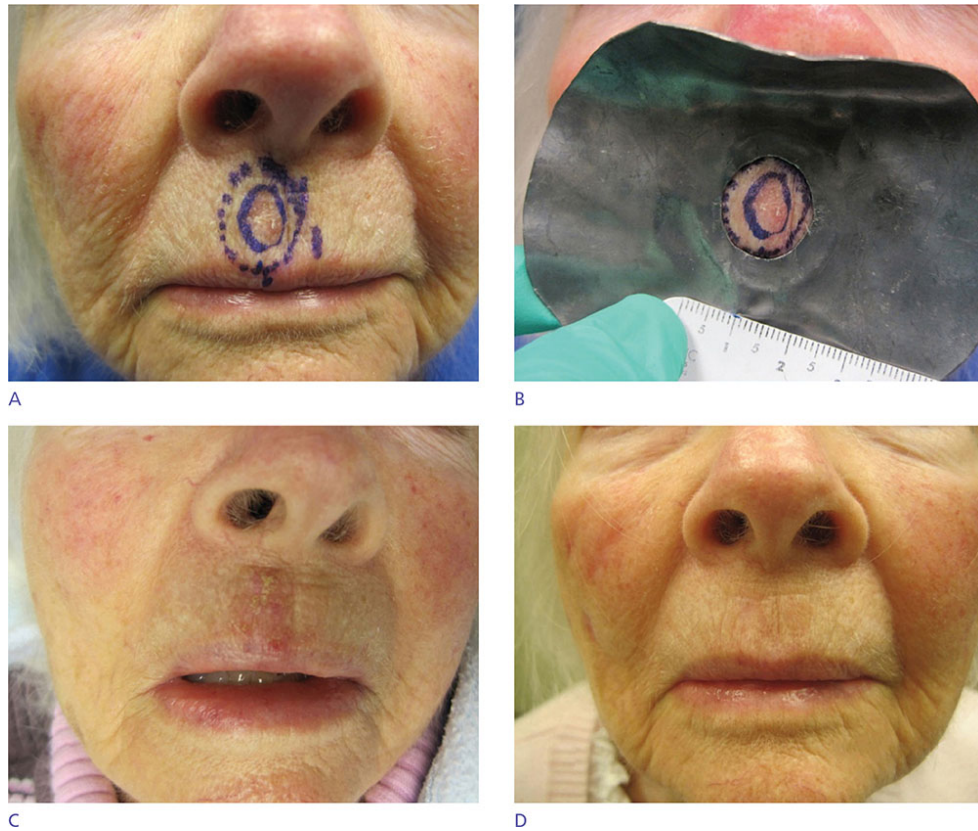


Figure 37-3. Treatment of an in situ squamous cell carcinoma of the upper lip with superficial radiation. This 83-year-old woman with a history of skin cancer was referred for the treatment of an actinic keratosis/squamous cell carcinoma in situ of the upper lip. Since she has a pacemaker and was being treated with warfarin, she wished to avoid surgery. The cancerous lesion was identified and circled and an additional 5- to 7-mm border was drawn around this. A 0.762-mm-thick lead shield was fashioned to include a 1.5×1.7 cm field and placed over the lesion and extended treatment field, and the eyes and thyroid were shielded. Using a 2.5-cm cone, nine fractions of 460 cGy (4140 cGy total) were delivered at 50 kV, 10 mA with a $D_{1/2}$ of 5.8 mm over a 3-week period. The patient tolerated the treatment well with only minimal erythema. The patient achieved a good cosmetic outcome at 2 months. (A) The cancerous lesion was identified and circled and an additional 5- to 7-mm border was drawn around this. (B) A 0.762-mm-thick lead shield was fashioned to include a 1.5×1.7 cm field and placed over the lesion and extended treatment field, and the eyes and thyroid were shielded. Using a 2.5-cm cone, nine fractions of 460 cGy (4140 cGy total) were delivered at 50 kV, 10 mA with a $D_{1/2}$ of 5.8 mm over a 3-week period. (C) The appearance of the lesion on the last day of treatment. (D) The patient achieved a good cosmetic outcome at 2 months.



Figure 37-4. Treatment of a squamous cell carcinoma of the left anterior lateral tibia. This 1.8×1.6 cm lesion was treated with SRT using a 1.0-cm margin. A 0.763-mm-thick lead shield was custom fashioned to a shield size of 3.2×3.2 cm. A 4.0-cm cone was initially selected to deliver 50 kV of 327.8 cGy at three fractionations per week with a treatment time of 0.44 minute per fractionation and a TDF of 99. The radiation prescription was changed after the seventh treatment (2294.6 total cGy delivered) in order to change to a larger 5.0-cm applicator. As a result, new values needed to be calculated for the total fractionation dose—three fractionations per week of 50 kV of 338.4 cGy for eight fractionations (2707.2 cGy total) with a treatment time of 0.45 minute per fractionation and a TDF of 99. The patient's total dose for this squamous cell carcinoma, located on the left anterior lateral tibia, totaled 5001.8 cGy over 23 fractionations. (A) Pretreatment. (B) 1 month postradiation. (C) 1-year postradiation.

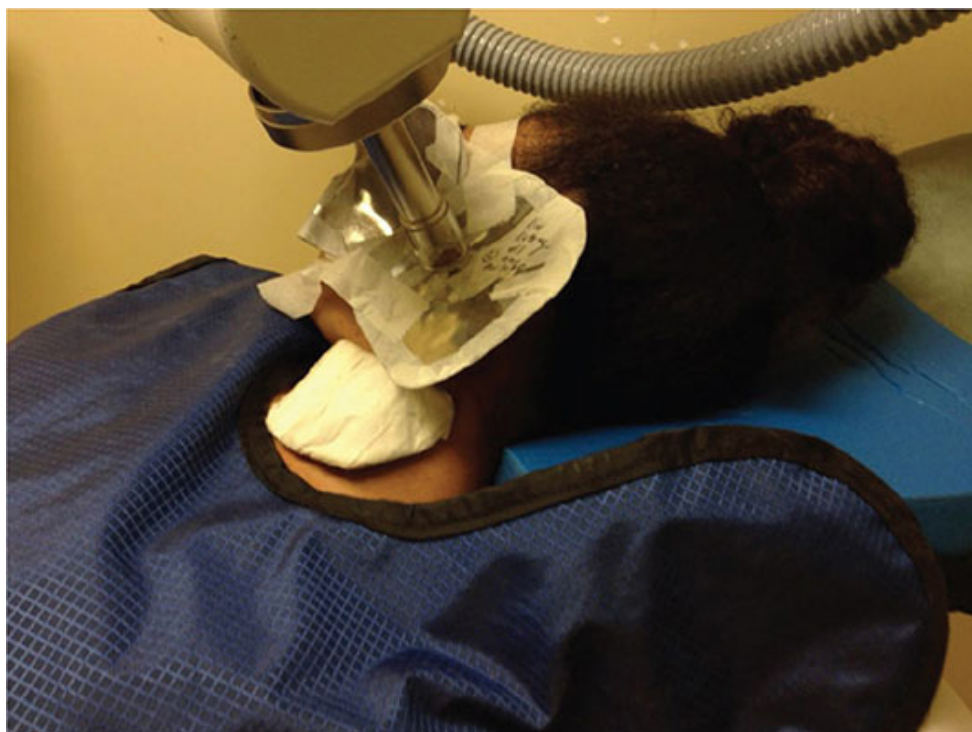


Figure 37-5. Ear keloid treated with SRT of 6 Gy on postoperative days 1 to 3.

RADIATION PHYSICS

Radiation can be produced electronically, as in x-rays or electrons, or via the disintegration of unstable isotopes, as seen in alpha, beta, and gamma rays. Isotope therapy such as brachytherapy, or implantation techniques, may result in a less homogenous dose pattern. In dermatology, when treating with radiation, most lesions are treated by teletherapy—electronically produced radiation delivered at a distance from the radiation source. Photonic teletherapy is the radiation source for SRT.¹⁷

EQUIVALENT DOSE

A biologic-dose-equivalent number is useful, as the total dose of radiation is dependent on the manner it is administered. This biologic-dose-equivalent number compares different fractionation patterns. It was developed when patches of skin were exposed to different courses of radiation and the degree of short-term (acute) damage produced posttreatment was used to define

equivalent doses. From these experiments it was realized that as a treatment regimen lengthened in time, the larger the numerical total dose needed to be in order to produce an equivalent reaction.¹⁷

As demonstrated in the formula below, the nominal standard dose (NSD) can be related to the total numerical dose (D), number of fractions (N), and total time of a radiation course (T):

$$D = \text{NSD} \times N^{24} \times T^{11}$$

where D is the total numerical dose, N is the number of fractions, T is the total time (in days) of course of radiation.

Orton and Ellis published a set of derivative tables written in time–dose–fractionation (TDF) units in order to simplify this calculation. These tables enable physicians to properly select the equivalent acute responses based on daily dose, number of fractions per week, and total number of fractions.¹⁷

While there is not a clear understanding on how damage is produced radiobiologically, there are at least two components to damage: alpha (α) and beta (β). Some cells are killed after a single interaction (α killing). The number of cells terminated by α killing is directly proportional to the dose-per-fraction. While some cells are destroyed by a single interaction, other cells are only damaged, and these cells apparently have multiple targets that need to be destroyed for the radiation therapy to be completely lethal (β killing). This β killing of cells is proportional to the square of the dose-per-fraction.¹⁷

Clinically, there are many applications of α and β killings. Individual tissues each have an intrinsic property of α -to- β killing ratio. Tumors and rapidly dividing tissues have an α/β ratio of approximately 10. For more slowly growing tissues (i.e., normal connective tissue), the α/β ratio is approximately 3. Late complications are thought to occur in slowly proliferating normal tissues. As such, late complications are worsened by large doses per fraction. A commonly depicted form of the alpha–beta model states that for an equivalent amount of short-term damage, larger daily fractions will result in greater long-term damage:¹⁷

$$E = n(\alpha d + \beta d^2)$$

where E is the cell kill (measured in logs), n is the number of fractions, d is the dose of a single fraction of radiation (Gray units).

This occurs since cells involved in long-term damage are preferentially affected by β killing. Practically, this suggests that while different radiation regimens are equivalent in treating and controlling cutaneous carcinomas, the regimen that uses a higher dose-per-fraction (while reaching the same total dose) will ultimately lead to worse long-term cosmesis.¹⁷

DOSIMETRY—THE $D_{1/2}$ CONCEPT

The depth to which x-rays can penetrate tissue before being absorbed is directly proportional to their energy.¹ The half-depth-value depth ($D_{1/2}$) is defined as the depth of tissue required to absorb or attenuate the x-ray beam by 50%. By knowing the desired $D_{1/2}$, the appropriate x-ray energy can be chosen to achieve the desired clinical effect while minimizing exposure to healthy underlying tissue. For skin cancers, the selected $D_{1/2}$ should be greater than the maximum measured depth of the tumor.¹

The quality of the radiation can also be improved by the use of filtering materials such as aluminum. When placed in the x-ray beam, filters absorb low-energy rays and increase the homogeneity and mean energy of those x-rays reaching the tumor while also increasing tissue penetration.¹ The total treatment time will increase, however, because filtration reduces the overall radiation intensity.

FRACTIONATION THEORY

Ionizing radiation damages both cancerous and normal cells; however, healthy cells exposed to sublethal doses of radiation are better able to repair themselves and survive than cancer cells. Therefore, administering the total dose of radiation in smaller fractions over longer periods will have maximal harmful effects on cancer cells but minimal effects on healthy cells. Thus, fractionation improves the therapeutic index of radiation therapy.

Various fractionation protocols may be used to accommodate the needs of each patient based on the size and location of the tumor, vascularity of the

tissue, and the sensitivity of the tumor to radiation.¹ Protocol modifications may include reducing the fraction size, increasing the number of fractions and total radiation dose, and changing the overall duration of treatment from the first fraction to the last. Modifying the size and number of the fractions and the total dose of administered radiation can prevent or minimize the occurrence of acute and latent radiation reactions while still optimizing the cure rate.

Acute reactions are defined as adverse events occurring within 90 days of administration of the first dose fraction. These reactions typically occur in areas of rapidly dividing normal cells within the treatment zone when doses of radiation are administered too frequently, and there is insufficient time for healthy cells to repair themselves. Common acute reactions include pain, erythema, and moist desquamation. Radiation doses exceeding 500 cGy per fraction in areas of low vascularity may lead to cell death and ulceration.

Latent reactions are defined as reactions occurring more than 90 days following the administration of the first fraction. These reactions can be controlled by monitoring the dose-per-fraction and the overall total radiation dose. Common latent reactions include skin atrophy, telangiectasias, and hypo- or hyperpigmentation. One of the most important innovations in radiation therapy is an improved understanding of the role of fractionation in improving outcomes and minimizing acute and latent effects.

FRACTIONATION TABLES

The TDF table provides a choice of protocols for a course of SRT based on the total dose of radiation, number of fractions, and duration of treatment (Table 37-1). This table is based on the work of early investigators who established clinical relationships between the radiation dose and fractionation to cancer cure and adverse effects.^{18,19} The TDF table provides the number of treatment fractions on the x-axis and the radiation dose for each fraction on the y-axis. It is generally assumed that treatments will be administered three to five times weekly; therefore, it will take 5 to 8 weeks to administer 24 fractions.

Table 37-1. Time–Dose Fractionation Factors^a

and neck lesions. Commonly used fractionation schedules used for treating skin cancers are shown in [Table 37-2](#).

Table 37-2. Common Fractionation Protocols Used for Treating Skin Cancers

TDF Number	Radiation Dose/Fraction (cGy)	Fractions/Week	Total Fractions	Total Radiation Dose (cGy)
98	380	3	12	4560
100	380	2	13	4940
100	320	3	16	5120

TREATMENT INTERRUPTIONS

A full course of SRT typically requires several weeks, and treatment may be interrupted for various reasons before completion. In these cases, a Decay table should be consulted when treatment resumes ([Table 37-3](#)). The number of completed treatment days is indicated on the y-axis and the length of the rest or interruption is indicated on the x-axis. These values correspond with the adjusted TDF number that should be used for the remaining duration of therapy.

Table 37-3. Decay Factors for Disrupted or Split-Course Radiotherapy

Treated Days (T)	Rest Period (R)											
	5	10	15	20	25	30	35	40	50	60	80	100
5	0.93	0.89	0.86	0.84	0.82	0.81	0.80	0.79	0.77	0.75	0.73	0.72
10	0.96	0.93	0.90	0.89	0.87	0.86	0.85	0.84	0.82	0.81	0.79	0.77
15	0.97	0.95	0.93	0.91	0.90	0.89	0.88	0.87	0.85	0.84	0.82	0.80
20	0.98	0.96	0.94	0.93	0.91	0.90	0.89	0.89	0.87	0.86	0.84	0.82
25	0.98	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.87	0.85	0.84
30	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.87	0.85
35	0.99	0.97	0.96	0.95	0.94	0.93	0.93	0.92	0.91	0.90	0.88	0.86
40	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.93	0.91	0.90	0.89	0.87
45	0.99	0.98	0.97	0.96	0.95	0.95	0.94	0.93	0.92	0.91	0.89	0.88
50	0.99	0.98	0.97	0.96	0.96	0.95	0.94	0.94	0.93	0.92	0.90	0.89

Note: Treated days are the number of completed treatment days prior to disruption. Rest period (days) was the duration of treatment disruption. The corresponding numbers are the decay factor, or adjusted TDF when treatment resumes.

FIELD SIZE

Due to the inability to histologically examine the margins of an irradiated tumor, treated tissue margins should be slightly larger than those required for a surgical excision. For a typical, well-demarcated lesion, margins of 1 cm

are sufficient. Large tumors and tumors with less well-defined borders may necessitate margins up to 2 cm.¹⁷ The use of customized lead shields limits radiation exposure to only the cancerous lesion and healthy tissue immediately surrounding it (Fig. 37-6).

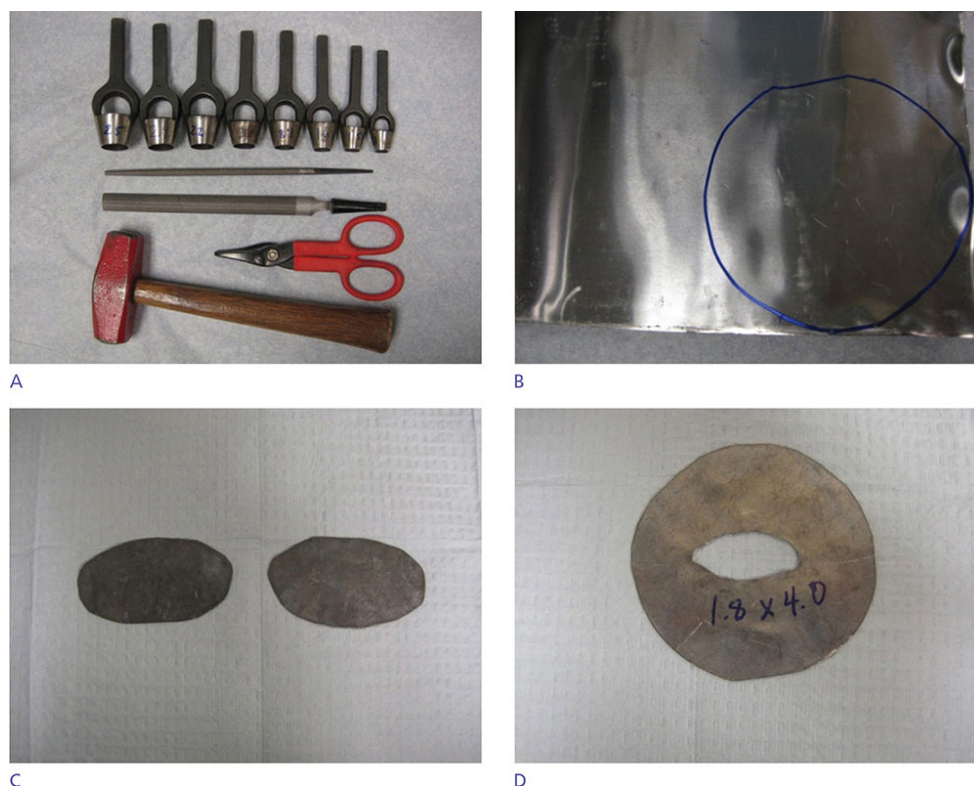


Figure 37-6. Custom lead shielding—using the tools shown, lead shields can be quickly fabricated to suit the needs of any patient undergoing SRT.

ALTERNATIVE RADIATION THERAPY MODALITIES FOR NMSC

Electron Beam Therapy

An alternative to SRT is electron beam therapy (EBT) whose energy source, an electron, is a charged particle; as such, EBT requires a linear accelerator. EBT is the treatment of choice by radiation oncologists to treat NMSC. EBT can be used to treat broader areas as well as deeper tumors in complex topographic treatment sites.²⁰ In the treatment of cutaneous malignancies with

EBT, radiation oncologists apply a bolus, a tissue-equivalent material, to the skin in order to shift the efficacious portion of the electron beam toward the skin surface.²¹

Superficial Radiation Therapy versus Electron Beam

In a review of cases treated at Mallinckrodt Institute of Radiology in St. Louis of 339 patients, cure rates of head and neck NMSC were slightly better when treated with SRT than EBT. This was felt to be due to a higher chance of underdosing EBT than SRT. For BCC with a size <1 cm, SRT had a cure rate of 97% (69/71) compared to EBT cure rate of 92% (11/12). For SCC with a size <1 cm, SRT and EBT cure rates were 100% (12/12) and 75% (3/4), respectively. In BCC measuring 1 to 1.5 cm, SRT cure rate was 93% (84/90) versus EBT cure rate of 73% (16/22). In SCC measuring 1 to 1.5 cm, SRT and EBT cure rates were 91% (10/11) and 70% (7/10), respectively. For larger BCC with a size >5 cm, SRT had a cure rate of 100% (4/4), while EBT cure rate was 92% (11/12). In SCC with a size >5 cm, SRT and EBT cure rates were 100% (1/1) and 75% (3/4), respectively.²² Still, there is an established role for EBT as adjunctive therapy in tumors with perineural invasion, treatment of cutaneous T-cell lymphoma (CTCL), Merkel cell carcinoma, dermatofibrosarcoma protuberans (DFSP), scalp tumors, and select melanomas of the head and neck.²⁰

High-Dose Rate Brachytherapy

High-dose rate (HDR) brachytherapy, an isotope therapy, involves the placement of radioactive sources directly onto or into target tissues.¹⁷ Several disadvantages limit the use of HDR brachytherapy, including a lower cure rate in NMSC that exceed a depth of 2 mm and a diameter greater than 2 cm. Even in ideal candidates, recurrence rates range from 0% to 10%. HDR brachytherapy also poses logistical challenges, as expensive hardware is required including applicators and sophisticated HDR after loading equipment. Additionally, there are potential risks of radiation exposure to medical personnel.²³

Electronic Brachytherapy

Electronic brachytherapy (E-brachytherapy) differs from HDR brachytherapy as it delivers surface brachytherapy without radioactive isotopes or linear accelerators. It is essentially SRT with the radiation source present closer to the skin. As a result, the need from extensive shielding, as required with HDR brachytherapy, is eliminated.²⁴ It also limits the size of the applicators to approximately 50 mm versus 180 mm for SRT. In a clinical study involving 122 patients with 171 NMSC lesions, E-brachytherapy was administered at 40 Gy in 8 fractions and delivered twice weekly. These patients were followed up to 1 year with good cosmetic results—no marked atrophy, gross telangiectasias, severe induration, loss of subcutaneous tissue, ulceration, or necrosis.²⁵

Two prospective, single-center, nonrandomized, pilot studies treated 40 patients (20 patients in each study) with E-brachytherapy for superficial and nodular BCCs. Group 1 patients received 36.6 Gy in 6 fractions of 6.1 Gy resulting in a 90% response at year 1 and Group 2 patients received 42 Gy in 6 fractions of 7 Gy resulting in a 95% response at year 1; both groups exhibited acceptable cosmesis.²⁶

Summarized data presented in abstract format at national meetings demonstrated a recurrence rate of less than 1% with E-brachytherapy. Most lesions were BCCs (57%) or SCCs (38%) less than 2 cm in size (97%). These NMSC lesions were treated with 40 to 45 Gy using mostly 8 fractions. Good cosmetic results accompany the recurrence rate of less than 1%, but these results are limited by a median follow-up of only 4 to 16 months.²⁷ Thus further study is needed to better quantify both response and recurrence rates.

CLINICAL EFFICACY OF SRT FOR NONMELANOMA SKIN CANCERS

Several retrospective studies have evaluated the safety and efficacy of SRT for the treatment of more than 3000 BCCs and SCCs.^{3,5,28,29} One retrospective analysis was performed on 1715 histologically confirmed primary cutaneous BCC and SCC treated with superficial x-ray therapy at a

single site over a 10-year period (2000–2010).³ These included 712 histologically proven BCC (631 nodular and 81 superficial), 994 SCC (861 in situ and 133 invasive), and 9 with distinct features of both BCC and SCC in the same biopsy specimen. Kaplan–Meier estimates (95% CI) of cumulative rates of tumor recurrence at 2 and 5 years were 1.9% (1–2.7%) and 5.0% (3.2–6.7%), respectively. The recurrence rate for BCC at 2 and 5 years was 2% (0.8–3.3%) and 4.2% (1.9–6.4%), respectively, and 1.8% (0.8–2.8%) and 5.8% (2.9–8.7%) for SCC, respectively. Tumors on male patients >2 cm in diameter were associated with a significantly increased likelihood of recurrence. This study, the largest to date, represented the experience of a single dermatology office. Others have reported 5-year cure rates for BCC and SCC to be 94.4% and 92.7%, respectively, following SRT and 15-year cure rates to be 84.8% and 78.6%, respectively.²⁸ Tumor control was 98% for lesions <1 cm, 93% for lesions 1 to 5 cm and 100% for lesions >5 cm.⁵

A retrospective review of 233 BCCs, some of which were recurrent, treated with radiotherapy with different fractions and levels of radiation was also performed. These BCCs were mostly on the face and scalp, with a few located on the trunk and extremities. Multiple fractions were used (an average of 10) and radiation levels ranged from <40 to >60 Gy, dependent on the size of the lesion. With a median follow-up time of 5.8 years, cure rates in previously untreated lesions was 94% and in recurrent lesions was 90%. A cosmetic rating of good or excellent was achieved in 92% of lesions. A long-term side effect of soft tissue necrosis was experienced in 2%, while cartilaginous necrosis was seen in one lesion, and bone necrosis occurred in two lesions. Local tumor control, cosmetic result, and complications were related to the maximal diameter of the lesion and the pathologic tumor type. Treatment type, patient age, and duration of treatment were not found to be associated with response.³⁰

Another review of 1267 NMSC lesions (1019 BCC, 245 SCC, and 3 mixed types) were irradiated with energies from 45 to 60 Gy with 8 to 10 fractions. Five-year cure rates for BCC and SCC were 94.8% and 90.4%, respectively. 2.4% of all tumors recurred at the irradiated border, and recurrence was related to tumor size, thickness, and TDF number. Side effects included hypopigmentation (72.7%), telangiectasias (51.5%), erythema (44.5%), and hyperpigmentation (23.4%).³¹

A meta-analysis of 14 retrospective studies pooled 1018 primary SCC lesions treated with radiotherapy of various energies and fractions. With a mean duration of follow-up between 2 and 5 years, the average local cure rate was 93.6%, while age and tumor size were correlated with risk of local recurrence (6.4%). Importantly, none of the studies had a mean duration of follow-up greater than 5 years.³²

Radiation Therapy Side Effects

Radiation dermatitis, with associated erythema, vesiculation, and ulceration, is a known side effect of SRT.³³ Acute reactions, such as erythema and mild discomfort, are to be expected and can be treated with mild emollients. Expected healing time of acute reactions is approximately 4 weeks after cessation of radiation therapy. Late reactions occur months to years later and can include hyperpigmentation, hypopigmentation, telangiectasias, and skin atrophy. These late reactions can be irreversible or may require more extensive treatment; for example, radiation-induced ulcers may benefit from debridement, skin grafts, antibiotic therapy, and other interventions.³⁴ Dyspigmentation and telangiectasias are seen frequently, and unlike surgical scars, which tend to improve over time, long-term sequelae of SRT tend to worsen over years and decades. Therefore, this approach should be used with extreme caution in younger patients.

Radiation Therapy Caveats

The proper and judicious use of superficial photon RT is critical; while there is a long tradition of dermatologists using radiation, it should always be utilized in the appropriate setting and for the appropriate patient.³⁵ Treatment failures with radiation can and do occur, though they may be minimized by careful selection of lesions and a thorough understanding of tumor subtype, depth, and clinical extension. Based on these factors, an appropriate depth dose, field size, and radiation plan and dosimetry will help secure a good chance of cure; however, other factors are needed to assure that the prescribed dose is delivered with minimal to no deviation during the course of fractionation. To reliably deliver the dose to the tumor bed, proper patient positioning, immobilization, and shielding can be repeatedly tested and fine-

tuned during simulation. Any variance in shield position or RT cone contact can result in the undertreatment of a tumor.

Old vs. New Radiation Devices

Newer machines have built-in safety features such as automated filtration placement, daily internal rad check, calibration, and desired and cumulative dose display during treatment. Many older machines accept added filtration to harden the beam for deeper tumors and require extra precautions, since failure to place the filter will lead to overtreatment, while failure to remove the filter for other calibrated depth dosages will lead to undertreatment.

Other concerns with older units include the need to be warmed up prior to treatment, and lack solid-state design necessitating careful monitoring and adjustment of the voltage and current during treatment. Older machines may allow the use of various cones with different target skin distances which require strict attention to calibration tables to avoid under- or overdosing. This is because photon RT output is inversely dependent on the square of the distance from the energy source. The calculation of dose in both older and newer machines should include a redundant hand calculation of the dosage using calibration tables specific to each machine at each different voltage settings, cone sizes and target skin distances.³⁶ Thus, with proper attention to detail and safety checks, both older and newer devices are reasonable options for the delivery of SRT.

USE OF RADIATION THERAPY FOR RECURRENT KELOIDS

In addition to being utilized for the treatment of NMSC, SRT can be utilized for treating recurrent keloids. Hypertrophic and keloid scars are common, and in addition to being cosmetically bothersome, may be symptomatic as well. Traditional treatments include topicals, intralesional 5-fluorouracil (5-FU), and intralesional steroids. Surgical excision has been used as well, but is similarly associated with a not insignificant recurrence rate. In a literature review of studies from 1942 to 2004 regarding the treatment of keloids with

either scalpel or laser excision, the weighted average recurrence rate was 71.2%.^{37,38}

Keloid recurrences can be significantly reduced with postoperative SRT. In a retrospective study of 80 keloidectomy patients treated postoperatively with a single fraction of 10 Gy radiotherapy, a 1-year relapse rate of 9% and a 5-year relapse rate of 16% were seen.³⁹

Another retrospective study of 76 ear keloids, the 5-year relapse-free rate was 79.8%. These keloids were treated postexcision with 5 Gy/week (a total dose of 25–45 Gy) of contact or superficial radiotherapy 1 to 3 days postoperatively. The mean follow-up was 47.85 months, and there were no adverse events of pigmentation or telangiectasias.⁴⁰

Ideally, radiation treatment for keloids should be administered within 2 days of surgical excision. A biologically effective dose (BED) value of 30 Gy can be obtained through multiple methods: a single acute dose of 13 Gy, 2 fractions of 8 Gy, 3 fractions of 6 Gy, or a single dose of 27 Gy at a low-dose rate. This radiotherapy regimen is recommended to keep keloid recurrence rates less than 10%.²

Most protocols implementing SRT postsurgical excision of keloids involve healing by primary intention, but a small study investigating radiation therapy for the prevention of keloids after shave excision resulted in no recurrence at a 5-month follow-up. With the shave excision, wounds were allowed to heal by secondary intention for 69 days. This time period was followed by three radiation treatments.⁴¹

EBT can also be selected for treatment after keloidectomy. One study examined the treatment of 91 keloids with combination surgical excision and postoperative electron beam radiation. 20 Gy were delivered at 5 fractions, but the protocol was modified for keloids on the ear to 16 Gy at 4 fractions. This study demonstrated a recurrence rate of 44%, though the presence of symptoms was considered a recurrence.⁴²

CONCLUSIONS

There has been a recent increase in the use of SRT for treating nonaggressive BCC and SCC. This resurgence is due in part to the availability of new

equipment, though reimbursement trends may be responsible for some of this increased interest as well.

SRT is a viable nonsurgical option for the treatment of select nonaggressive primary BCCs and SCCs in patients where surgical intervention is refused or inadvisable. While not a first-line treatment for most NMSCs, SRT is well suited for use by dermatologists in the office setting.

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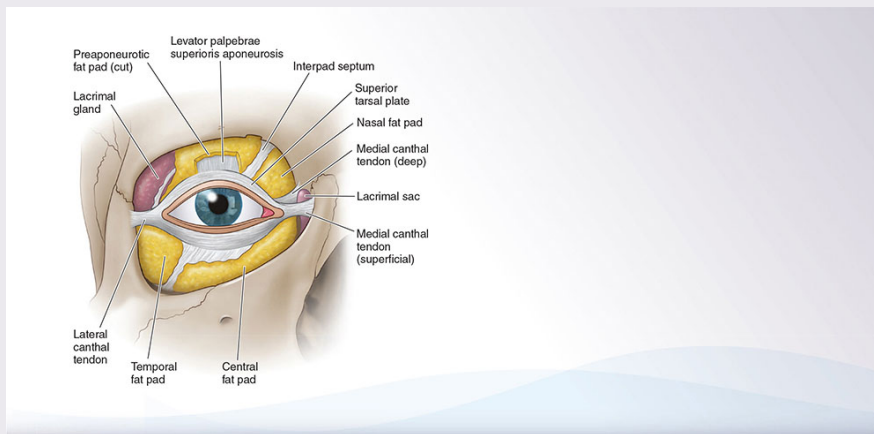
Part III

REGIONAL APPROACHES TO RECONSTRUCTION

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CHAPTER 38 Reconstruction of the Eyelids

Andrea Willey
Richard Caesar



SUMMARY

- Eyelid reconstruction lies at the crossroads of multiple surgical specialties, and presents distinct challenges for the periocular surgeon.
- The unique multilaminar composition of the eyelids, freely mobile yet bound by fixed bipolar attachments, is vulnerable to tensional forces that require diligent management to preserve their unique anatomic and functional relationships.

Beginner Pearls



- Preoperative evaluation and collaboration with ophthalmic and oculoplastic specialists when indicated is essential for optimal outcomes.
- Knowledge of and familiarity with the management of tension are essential to periocular surgery.
- Tension on the lid margin should be assessed pre-, post-, and intraoperatively to ensure the lid remains in optimal position snug against the globe.

Expert Pearls



- Keeping tension parallel to the lid margin is the cornerstone of periocular repairs, and is often balanced with placing incisions along relaxed skin tension lines.
- Transposition flaps and rotation flaps are useful for many periocular defects.
- Primary repair of full-thickness lid defects is fundamental to more advanced reconstructive techniques.

Don't Forget!



- Reconstruction of larger full-thickness lid defects involves a progressive approach with a combination of techniques to repair the anterior and posterior lamella.
- Suspension sutures should be used routinely to support periocular repairs and avoid ectropion, even when the canthal support has not been disrupted by tumor extirpation.

Pitfalls and Cautions



- Full-thickness skin grafts must be appropriately sized with the defect on full stretch to avoid excessive wound contraction and ectropion.
- Complications include bleeding, infection, hematoma, chemosis, epiphora, dry eye, suture granuloma, trichiasis, lid notching, scleral show, asymmetry, ectropion, and webbing.
- Even mild ectropion can cause significant epiphora and discomfort and may require a slit-lamp examination to evaluate for corneal abrasion.

Patient Education Points



- Select patients undergoing extensive surgery around the eye may have a preoperative ocular examination and consultation with an oculoplastic surgeon to ensure a smooth transition of care if needed.
- Both ectropion and webbing tend to occur 2 to 4 weeks postoperatively during maximal wound contraction. Correction usually requires flap revision and canthopexy procedures.

Billing Pearls



- Excisions and repairs on the eyelid rely on the standard code series; keep in mind that placement of suspension sutures in a linear repair is likely sufficient to elevate a layered closure to complex status.

CHAPTER 38 Reconstruction of the Eyelids

INTRODUCTION

Eyelid reconstruction lies at the crossroads of multiple surgical specialties, and presents distinct challenges for the periocular surgeon. The unique multilaminar composition of the eyelids, freely mobile yet bound by fixed bipolar attachments, is vulnerable to tensional forces that require diligent management to preserve their unique anatomic and functional relationships. The eyelids not only protect the globe and provide a tear film necessary for visual perception, but also hold great aesthetic significance. An understanding of anatomy, principles, and fundamental techniques of periocular surgery is a prerequisite for addressing methods of managing tension on the eyelids.

PREOPERATIVE ASSESSMENT AND MANAGEMENT

A thorough ocular history and examination assessing visual acuity, intraocular pressure, and tear film/dryness may be recommended before surgery. A preoperative consultation with an oculoplastic surgeon is prudent for patients who are likely to need multispecialty collaboration, or patients with significant pre-existing eye disease. In addition, conditions of dry eyes or xerophthalmia should be diligently managed in the perioperative period. For recurrent tumors or tumors with suspected extension into the orbit or medial canthal structures, imaging with CT or MRI may be indicated. Taking clinical photographs before and after surgery is prudent for all patients.

Instrumentation and preparation

Bishop Harmon forceps

Wescott spring scissors

Stevens tenotomy scissors

Castroviejo needle holders

Desmarres retractor

Jaeger lid plate

Bowman lacrimal probe

Cox II metal shields

Fine tissue hooks

Calipers

Bipolar unit or hot loop cautery

5-0, 6-0, 7-0 polyglactin sutures spatulated needles

6-0 polypropylene sutures

Proparacaine hydrochloride ophthalmic drops

2% lidocaine hydrochloride with epinephrine

Erythromycin ophthalmic ointment

Nonstick eye pads

Metal or plastic eye shield

Assessment and control of potential bleeding is necessary to prevent complications during periocular surgery. Management or cessation of anticoagulants is indicated for large tumor extirpations or repairs that breach the orbital septum to minimize the risk of retrobulbar hemorrhage. Control of blood pressure in hypertensive patients is also important to minimize risks of

bleeding. Meticulous intraoperative control of bleeding and postoperative observation and counseling is essential. In addition, anxiolytic medications with appropriate monitoring can be useful during periocular surgery.

The periocular skin is cleansed with povidone–iodine or hypochlorous acid antiseptic.¹ Chlorhexidine solution is contraindicated as a periocular prep agent, as it may lead to complications including keratitis, corneal opacification, and ulceration.² Local anesthetic with epinephrine is infiltrated subcutaneously, and transconjunctivally, as this is usually less painful for repairs involving the eyelid itself. Adequate time must be allowed for the vasoconstrictive effects of epinephrine to take effect. Topical anesthetic ophthalmic drops are applied prior to placement of a corneal shield.

Plastic or metal corneal shields can be useful to protect the globe from trauma and light during surgery, but are not mandatory if care is taken while working around the eye. Corneal shields must have a smooth surface and fit properly. Care should be taken so that caustic substances do not get under the shield, which can damage the cornea.

ANATOMY

A comprehensive understanding of the distinct anatomic features of the eyelids is necessary for repairing surgical defects of the eyelids and periocular skin.³ The eyelids are a multilaminar structure comprising conjunctiva, tarsus, muscle, and skin, with various incorporated glands and appendages. The eyelids are suspended firmly to the bony orbit by tendons at the lateral and medial canthi and loosely surrounding soft tissue layers. Eyelids protect the globe and harbor glands that create the outer oil layer of the tear film required for clear vision. The relationships and attachments between the eyelid and surrounding soft tissue are essential for eyelid mobility and are the crux of expression and beauty.

The upper lid tarsus is curved in the shape of the globe where it rests smoothly along the surface with the medial puncti exposed to the lacrimal lake on blinking. The skin of the eyelid is thin, adherent over the tarsus of the palpebral lid. The posterior edge of the lid margin is sharper than the more rounded anterior edge with emanating lashes. This anatomic feature is a useful landmark for primary lid closures. The tarsus provides the structural

support of the lid. The tarsus also houses the meibomian glands, which secrete the oily portion of the tear film that keeps tears from evaporating.

Conceptually, the lid is divided into anterior and posterior lamella, defining a plane of surgical division, which may be reconstructed independently. The posterior lamella is comprised of the conjunctiva and tarsus, the structure of the lid, and its mucosal lining, while the anterior lamella is comprised of the skin and orbicularis muscle. The orbicularis muscle consists of the orbital portion, which acts like a sphincter by forming an ellipse within the orbit and converging at the medial raphe of the canthus, and the tarsal and septal palpebral portions, which overlie the upper and lower tarsi, respectively.

The palpebral orbicularis oculi muscles become contiguous with canthal tendons laterally before attaching to Whitnall's tubercle, a bony prominence inside of the bony orbit, 4 mm posterior to the orbital rim just superior to the canthal apex. Whitnall's tubercle is also the site of convergence of Whitnall's and Lockwood's ligaments, the pulley system of the lid motion and the supportive tissues of the lateral retinaculum. Medially the orbicularis muscle forms the complex structure of the lacrimal pump, dividing into superficial and deep heads around the lacrimal canaliculi before attaching to the bony orbit at the maxilla and anterior and posterior lacrimal crests housing the lacrimal sac.

The vascular supply of the upper and lower eyelids supplied by the internal and external carotid arteries is comprehensive and generous, allowing for ready healing of surgical wounds ([Fig. 38-1](#)). Inferiorly the facial artery joins the dorsal nasal artery at the medial canthus just medial to the attachment of the canthal tendon to supply the upper and lower lids. The superficial temporal, lacrimal, and transverse facial arteries anastomose to form upper and lower palpebral arcades.

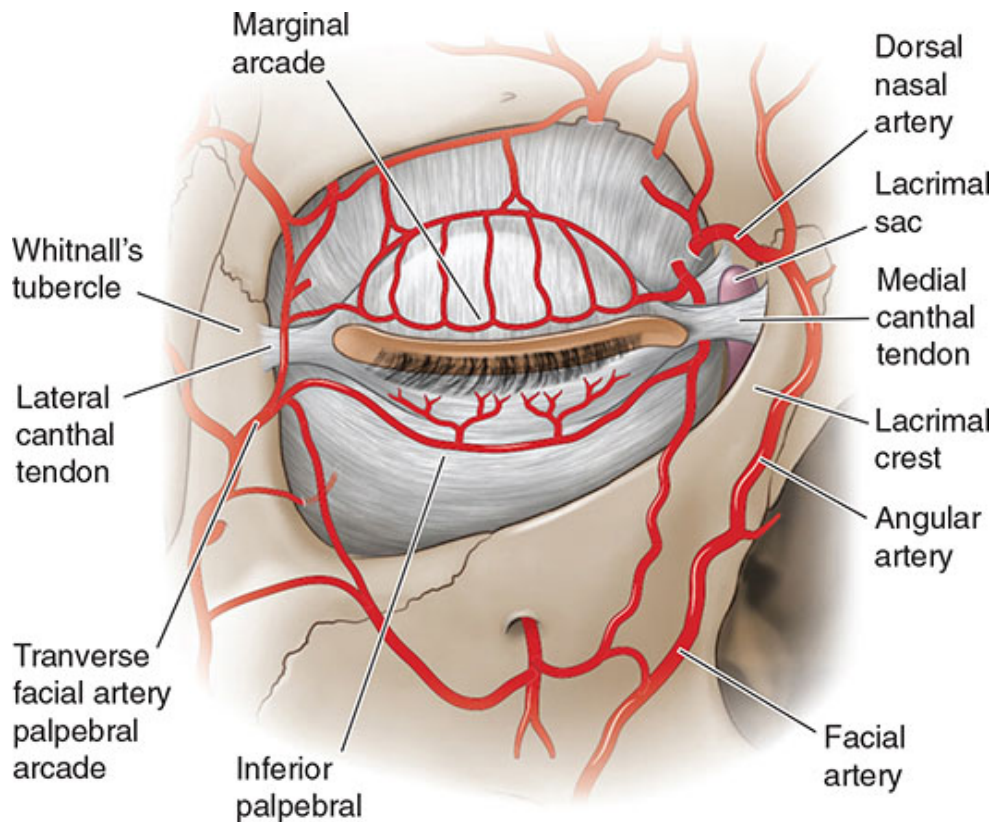


Figure 38-1. Periocular vascular anatomy.

The muscular innervation of the orbicularis is supplied by numerous branches of the facial nerve, which are responsible for both the constitutive tone as well as the active sphincter-like motion of the orbicularis. When muscular innervation is compromised, osteocutaneous suspension sutures are useful to maintain the position of the eye and prevent ectropion. Sensory innervation of the orbicularis is supplied by numerous branches of the trigeminal nerve. Sensory and sympathetic motor nerves of the globe originate from the ciliary ganglion.

PERIOCCULAR TENSION MANAGEMENT

An intimate understanding of tension capacity of the eyelids relative to surrounding structures, and the varying degrees of laxity that come with age, is essential to avoid complications of ectropion and webbing. Highly sensitive tensional forces on the eyelid are created by the combined effects of thin and mobile skin of the eyelids and soft tissue, which are fixed to the

bony orbit bilaterally and surrounded by thicker skin bound to the underlying retinaculum.

These unique relationships allow for the mobility of the eye and are necessary for the lids to open and close and for concentric movement of the orbicularis. However, this mobility of skin and soft tissue also reacts readily to external forces, including gravity and wound contraction. As the bony structures of the orbit change with age, the soft tissue and tendinous attachments loosen, creating a lower threshold for tensional forces to pull the lid away from the globe and can disrupt the function of the lids and lacrimal puncti. Similarly, the thin and mobile skin of the medial canthus, tethered by more firmly attached surrounding skin that facilitates the vertical movement of facial expression, moves readily to create a web. Knowledge and appreciation of these tensional forces is invaluable in maintaining function of the eye and avoiding the pitfalls of ectropion and webbing.

Preoperative assessment of the degree of laxity of the lower lid is typically done by assessing how far the lid distracts downward when gently pulled or how rapidly the lid snaps back when pulled away from the globe. Easy distraction or slow recoil indicates a lower threshold for vertical tension during lid repair and wound contraction. An appreciation for the degree of normal tension can be gained with experience. The degree of lid tension is assessed intraoperatively and postoperatively by having the patient simultaneously gaze upward and open the mouth widely. If the lid pulls away from the globe during this maximal vertical tension, additional support is needed, usually in the form of flap adjustment, suspension sutures, and/or canthopexy.

CANTHOPEXY AND SUSPENSION SUTURES

Numerous canthopexy procedures have been described for effective support of the lid margin and canthi during periocular surgery.⁴⁻⁶ Suspension sutures can be placed in periosteum along the orbital bone or through retinaculum and fascial layers to support flaps and grafts and actively minimize tension on the lid margin.⁷⁻¹¹ A simple lateral canthopexy can be performed through an existing defect or by making a linear skin incision a few millimeters lateral to the lateral canthus followed by blunt dissection to the orbital rim. A metal shield is used to protect the globe as a 5-0 polyglactin suture on a

spatulated needle is passed through the tarsus and then through the periosteum at a shallow angle (from inside to outside) along the inner orbital rim at Whitnall's tubercle. The suture is then carefully secured using graduated tension until the tarsus is delicately secured to the orbital rim without over tightening. Medially, flaps can be suspended to the periosteum medial to the insertion of the medial canthal tendon, or to the tendon itself.^{12–14} Care must be taken not to pass the suture into the underlying lacrimal structures.

RECONSTRUCTION OF ANTERIOR LAMELLAR DEFECTS

There are many options for reconstructing defects involving the periocular skin and eyelids, depending on the location, size and depth of the defect, the surrounding skin reservoirs, and laxity of the eyelids. The aim of periocular reconstruction is to repair the defect while maintaining the position of the eyelid, punctum, and canaliculi, avoiding vertical tension on the eyelid during surgery, and actively preventing any imbalance of tension associated with wound contraction during the perioperative period.

Linear Repairs

Linear repairs of wounds around the eye require a balance of keeping incisions perpendicular to the lid margin and obscuring incisions in relaxed skin tension lines (RSTL). Vertical incisions below the lid margin can be made in an increasingly oblique manner around the lower eyelid, except in the medial canthus where horizontal incisions are strictly avoided to prevent webbing (Fig. 38-2). Deep sutures can help to guide tension horizontally to allow for more oblique skin incisions. M-plasty repairs or simply leaving redundant cones can be useful for defects close to the lid margin. Small defects located on the upper lid crease can often be repaired with a traditional crescent-shaped blepharoplasty incision along the natural crease, keeping incisions lateral to the caruncle to avoid webbing and extending beyond the lateral canthus when hooding is present. Due to the mobility of skin inside the bony orbit relative to the surrounding thicker bound periorbital skin, even defects outside the orbit that are repaired with incisions directed perpendicular to the lid margin can result in ectropion

during wound contraction if the lid is sufficiently lax. Evaluating tension on the lid intraoperatively can help identify excessive tension. Periosteal suspension sutures can be placed around the eye when needed to support the lid during the perioperative period.⁷⁻¹¹

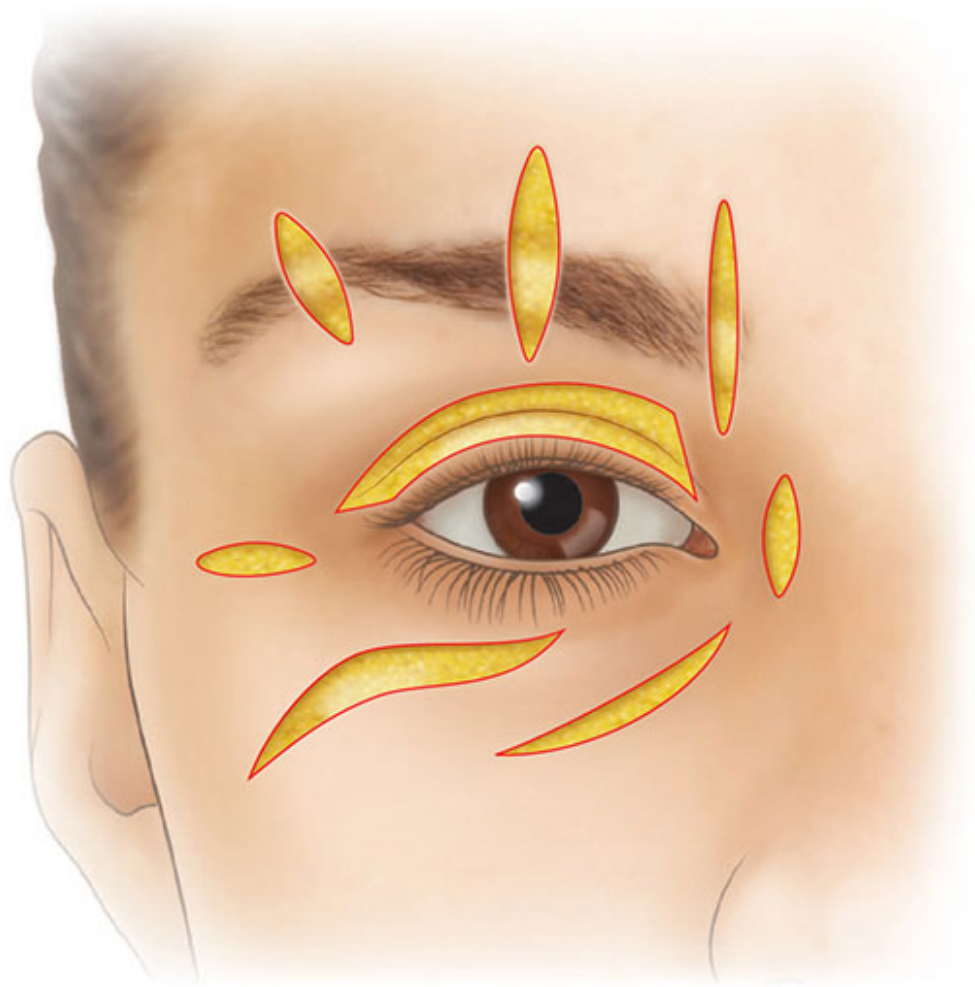


Figure 38-2. Linear repairs balance incision lines perpendicular to the lid margin and within relaxed skin tension lines. Vertical incisions can be made in an increasingly oblique manner around the lower lid, except in the medial canthus where horizontal incisions are strictly avoided to prevent webbing. Incisions on the upper lid can be made within the natural lid crease.

Skin Grafts

Full-thickness skin grafts are commonly used for anterior lamellar defects of the upper and lower lids and medial canthus when direct closures are not possible. Adequate sizing of grafts is imperative to avoid ectropion

associated with wound contraction. In general, grafts should be 25% to 30% larger than the defect when placed inside the bony orbit.¹⁵ More precise sizing for defects below the lid margin can be determined by placing the lower lid on full stretch upward with forceps or a suture to expand the defect maximally. A sterile nonadherent gauze pad can be used as a blotter to create a template with the lid on full stretch.^{16,17} Ipsilateral and contralateral upper eyelid crease provides the ideal tissue match and is well vascularized for rapid inosculation. Other donor sites include pre- and postauricular skin, supraclavicular, and inner arm skin. Grafts from these areas must be thinned significantly to improve tissue match and reduce bulkiness. Grafts can be fenestrated and tacked to the wound bed if needed. Dental wax or vaseline gauze bolsters can be used for gentle pressure postoperatively. Canthopexy sutures can be placed to support the lower lid and avoid ectropion associated with wound contraction. Modified Frost sutures can be placed to support the lid during the immediate postoperative period while tissue swelling may lead to tension on the lid margin.¹⁸ Split-thickness grafts are generally avoided in this area due to the possibility of excessive wound contraction.

Flaps

Numerous flaps have been used to successfully reconstruct the periocular area.^{19,20} While the characteristics of the defect and the surrounding tissue will determine the appropriate repair, a regional approach to periocular repairs according to surgical zones can be useful (Figs. 38-3 and 38-4).^{13,21–23} Regardless of choice of repair, it is imperative to design and support flaps and grafts in the perioperative period to minimize forces of gravity, edema, and wound contraction that may distract the lid away from the globe, causing complications of lid malposition, corneal exposure, lacrimal dysfunction, or suboptimal cosmesis. Ancillary suspension sutures, including medial and lateral canthopexy procedures, are used routinely during periocular repairs to prevent ectropion, especially in elderly patients with significant laxity, even if the eyelid or canthal support system is not disrupted by tumor extirpation.^{21,13} The following is a regional approach to periocular reconstruction and canthal support procedures that reliably repairs anterior lamellar and full-thickness lid defects.

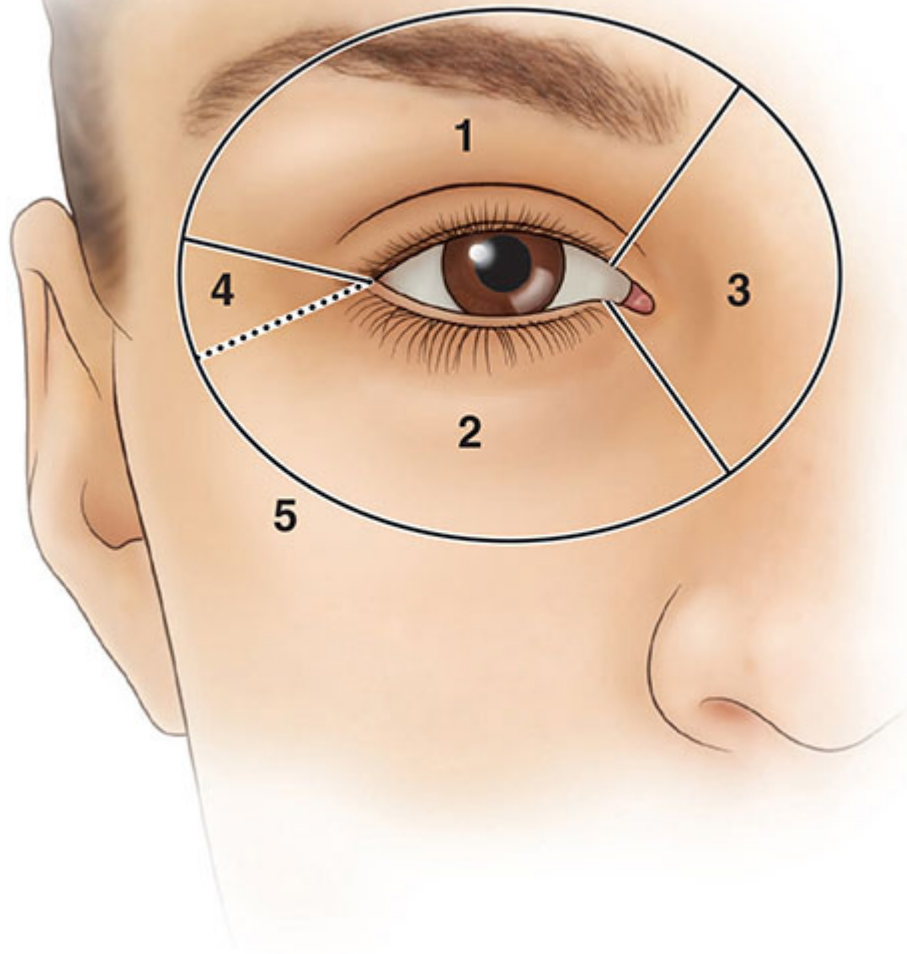


Figure 38-3. Modified zones of periocular reconstruction. Reconstructive options in the periocular region can be classified by surgical zone. 1. Upper lid. 2. Lower lid. 3. Medial canthus. 4. Lateral canthus. 5. Periorbital cheek. Reconstructive options for zones 2 and 4 are similar.

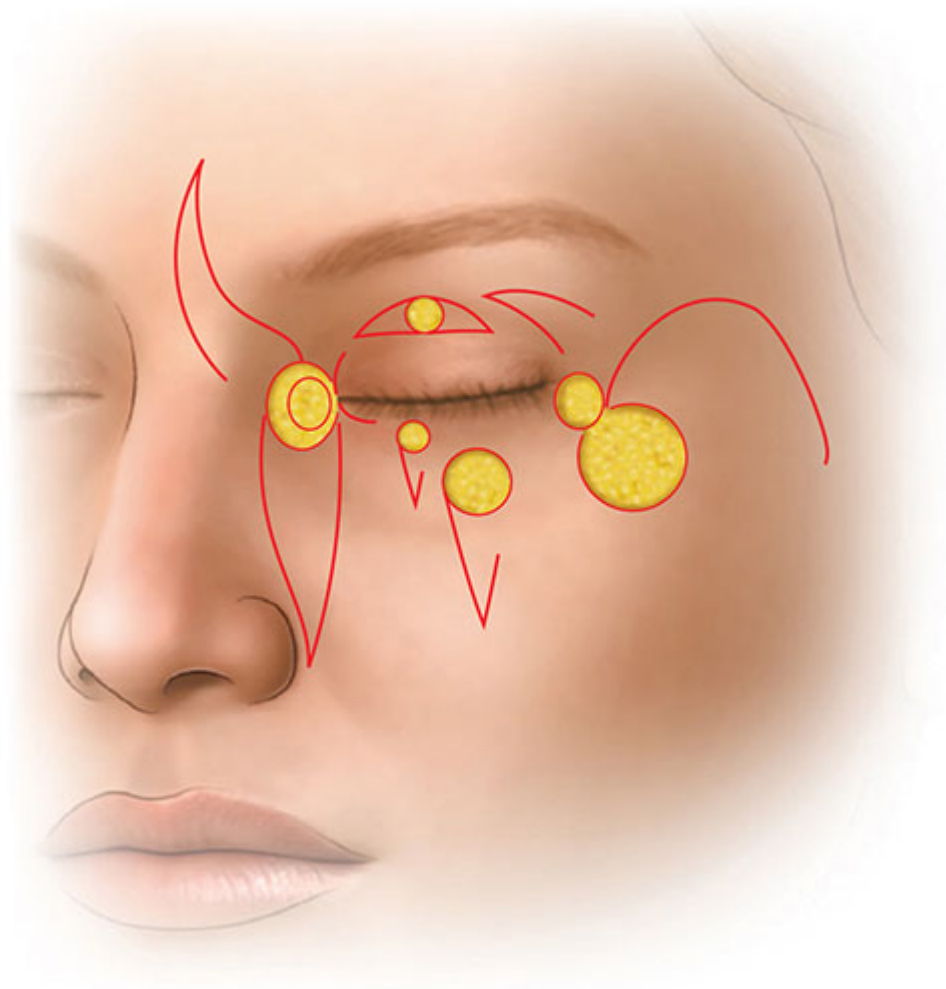


Figure 38-4. Regional approach to periocular flap repairs.

LOWER LID AND LATERAL CANTHI

Designing flaps with tension vectors parallel to the lid margin is a cornerstone of periocular reconstruction, particularly below the lid margin and at the lateral canthus where the lid is most vulnerable to distraction. Rhomboid transposition flaps that “push tissue” toward the lid margin, redirecting tension vertically and efficiently repairing wounds with minimal undermining beyond the flap, are workhorse flaps for small and medium defects below the lid margin and outside the canthi (Fig. 38-5). When adequately sized to minimize tension, scars are minimally visible despite crossing cosmetic unit borders. The size of the rhomboid flap must be large enough to account for pivotal restraint and secondary movement of the wound

edge, wound contraction, upward gaze, and maximal tension, as well as to avoid complications of ectropion. Transposition flaps based on the infraorbital cheek skin are useful for central defects below the lid, including those very close to the lid margin, as they soundly direct tension superiorly (Fig. 38-6). More lateral defects below the lid margin can be repaired with transposition flaps that use the redundant skin of the upper lid crease (Fig. 38-7).^{24,25} Canthal suspension sutures provide additional support when indicated. Laterally based rotation flaps are useful for defects exceeding the limits of the upper lid reservoir (Fig. 38-8).



Figure 38-5. Rhomboid transposition flap. (A) Defect below the lid margin. (B) Flap oversized to minimize vertical tension and prevent ectropion. (C) Lid snug against the globe with maximum tension postoperatively. (D) Tension-free flap 3 months postoperatively.



A



B

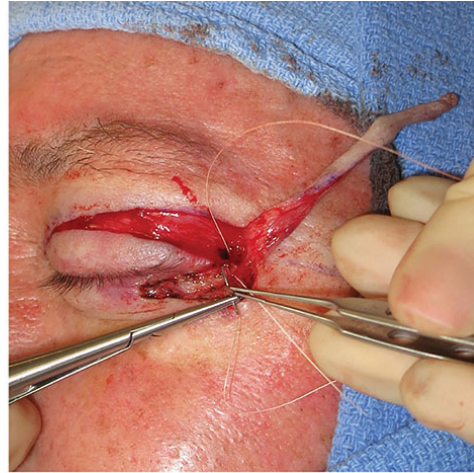


C

Figure 38-6. Rhomboid transposition flap. (A) Defect extending onto the lid margin. (B) Lid snug against the globe with flap in place intraoperatively. (C) Tension- free flap 3 months postoperatively.



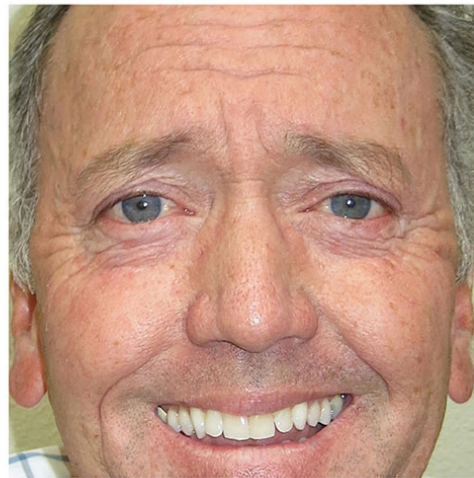
A



B



C



D

Figure 38-7. Tripier flap. (A) Defect close to the lateral canthus extending through the orbicularis. (B) Periosteal suspension suture is placed to support the cheek below the flap and relieve tension on the lid margin. (C) Lid margin snug against the globe with max tension postoperatively. (D) Tension-free flap 6 months postoperatively.



Figure 38-8. Temple rotation flap. (A) Defect exceeding reservoir on the upper lid crease. (B) Arc of rotation extending above the lateral canthus and incisions placed in RSTL. (C) Tension-free flap 2 months postoperatively with incision lines obscured in rhytids.

Larger defects below the lid margin are reliably closed with rotation flaps that take advantage of the ample cheek reservoir and partially obscure incisions in the subciliary and hair lines (Fig. 38-9).²⁶ Rotation flaps can lengthen the circumference of flaps and redistribute tension vertically beyond the canthi,²⁷ and thus are often preferred to straight advancement flaps, except for small vertically oriented defects that can be repaired with minimal tension. Ideally, incisions along the subciliary skin extend above and lateral to the outer canthus before curving downward along the hairline. This way, vertical tension originates lateral to the lid margin and incision lines can be

partially obscured in RSTL. Pivotal restraint can be reduced by placing a back cut in the hairline or behind the ear, but this is often not necessary.



Figure 38-9. Cheek rotation flap. (A) Large medial defect extending above and below the lid margin. (B) Flap undermined with the arc of rotation at the lateral canthus, incisions in RSTL, and ample tissue in the medial canthus. (C) Lid snug against the globe with maximal tension postoperatively. (D) Tension-free flap 5 months postoperatively.

Advancement flaps that slide tissue horizontally are effective for a variety of defects below the lid. Obscuring a portion of the scar in the subciliary border while displacing the dog ear beyond the canthi is advantageous, though undermining can be considerable for larger defects, and requires greater care within the orbital septum where retinaculum and adipose tissue are minimal. Dog ears can be repositioned, though tension vectors for advancement flaps are not redirected and wound contraction can still occur

in a vertical direction. Small vertical defects where redundant cones can be left standing are easily closed with purely horizontal advancement flaps.

Inferiorly based advancement flaps that easily mobilize the malar skin are useful for medial defects below the lid (Fig. 38-10). Vertical tension should be supported with periosteal sutures that anchor the weight of the flap securely to the nasofacial sulcus.



Figure 38-10. Cheek advancement. (A) Medial defect below the lid margin. (B) Periosteal suspension suture placed in the nasal bone secures the flap and removes tension from the lid. (C) Lid snug against globe upon maximal tension postoperatively. (D) Tension-free flap incisions obscured 2 weeks postoperatively.

Island pedicle V–Y advancement flaps are also useful for medium-sized defects below the lid margin when minimal undermining is needed, but must be robustly suspended to the periosteum to offset vertical tension. Suspension

sutures are placed far back from the flap margin so that the flap supports the lid with maximal tension on upward gaze. Island flaps are best designed carefully with a slightly undersized width so that tissue is pushed toward the lid with lateral tension vectors, and pin-cushioning is minimized.

Defects confined to the outer canthi are best repaired with inferiorly or superiorly based transposition and rotation flaps that utilize the skin reservoirs of the upper lid crease, temple, and lateral cheek areas.²¹ Suspension sutures can be placed in the orbital periosteum to support the canthal tissues and protect against ectropion. Bilateral rotation flaps can be used for defects above and below the canthal apex. Flaps should be suspended to the lateral canthal tendons to recreate the canthal angle. Full-thickness skin grafts, including adjacent tissue Burow's grafts, can be used when needed, as long as they are adequately sized and supported with pecking sutures to prevent distraction of the lid away from the globe.

UPPER LID

Defects involving the skin and muscle of the upper eyelid are routinely repaired with flaps and grafts fashioned from the adjacent or contralateral eyelid (Fig. 38-11). Flaps and grafts such as these provide tissue and robust vascularity for rapid wound healing and can often be hidden in natural creases. Blepharoplasty-type advancement flaps based on the lid crease can be ideal for superficial defects on the upper lid where the incision lines are made along the natural lid crease and redundant skin and muscle of the crease can be easily mobilized into defects (Fig. 38-12). Just as in a simple blepharoplasty, incisions are kept lateral to the caruncle and may extend beyond the lateral canthus when hooding is present. Full-thickness defects of the upper lid often require the expertise and management of an oculoplastic surgeon to preserve the functional components of the upper lid.

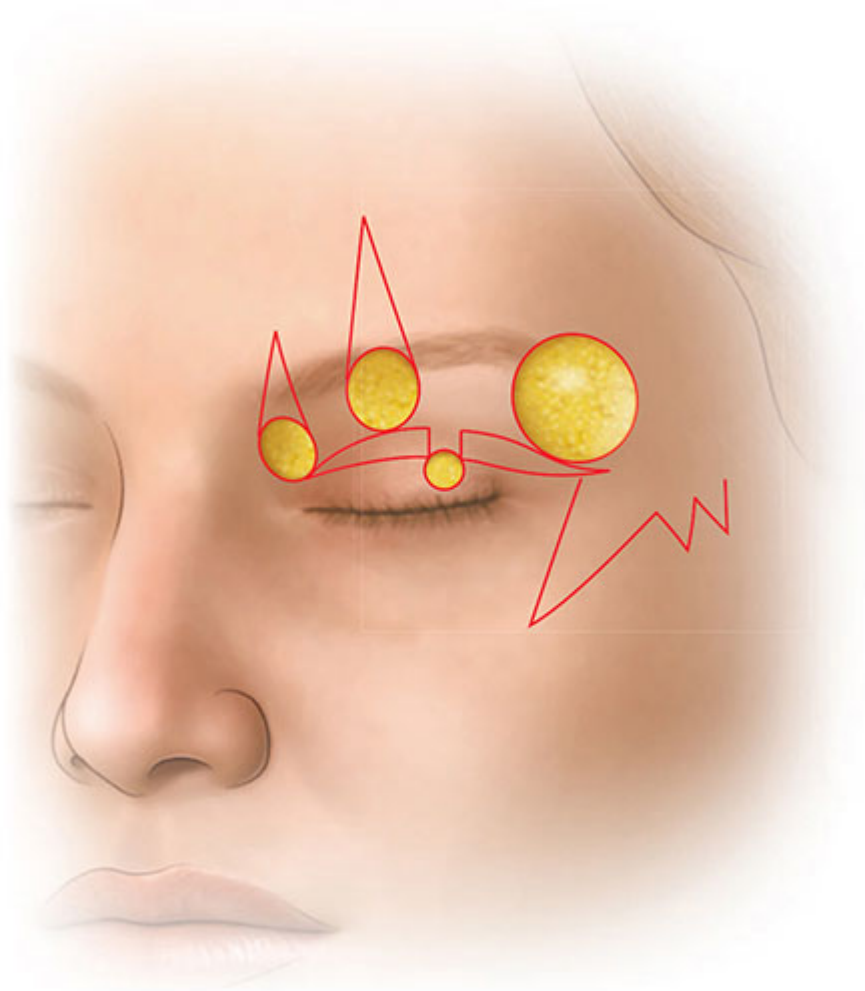


Figure 38-11. Defects on the upper lid can often be repaired with traditional or blepharoplasty-type advancement flaps with incisions along the lid crease. Transposition flaps can be useful for large defects.

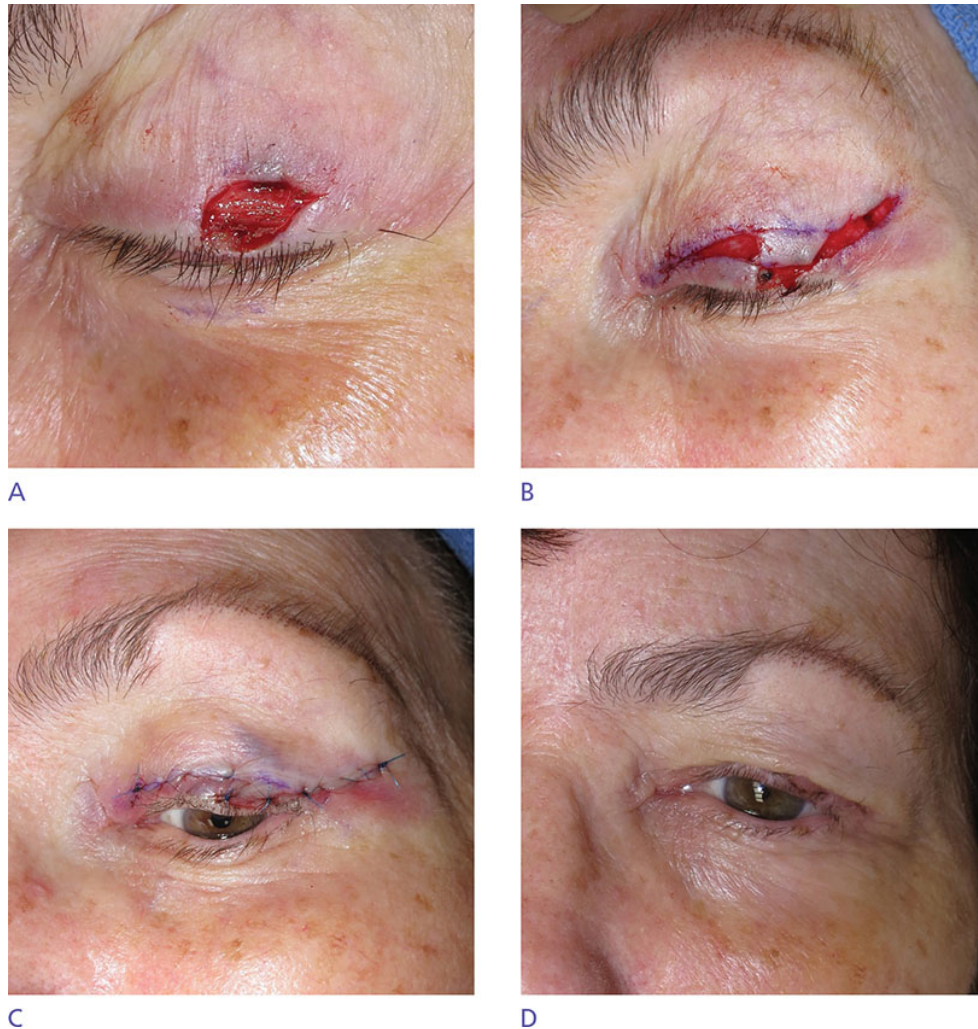


Figure 38-12. Blepharoplasty advancement flap. (A) Defect on the upper lid extending to the margin. (B) Flap incised with redundant cones removed from the upper lid crease. (C) Flap in place postoperatively. No sutures are placed along the lid margin to avoid irritation and corneal abrasion. (D) Tension-free flap 1 week postoperatively.

MEDIAL CANTHUS

The complex anatomy of the medial canthus creates distinct challenges for the periocular surgeon.^{29,30} Though it may worsen with age, the propensity of medial canthal skin to form a web is fairly constant. Webbing across the canthus occurs readily if not actively prevented, due to its concave contour, the need for vertical movement of the brows, and the thin mobile skin inside the orbital rim adjacent to the relatively thicker bound skin of the cheek and nose. Fundamental principles of reconstruction in the medial canthus that

minimize risks of webbing include designing flaps within the canthal subunits, sizing flaps, and grafts adequately to cover the concavity of the canthi and accommodate vertical movement of the muscles of facial expression, and suspending flaps to the periosteum and canthal support tissues to direct tension.¹²⁻¹⁴ Conceptually, the subunits of the medial canthi are defined by the attachments of the orbital rim that separate the more thin mobile skin inside the orbit from the thicker bound skin of the cheek and nose, and the horizontal apex of the medial canthus (Fig. 38-13).¹⁴ Combining flaps within the canthal subunits and suspending them to the canthal support tissue is a cornerstone of repairing canthal defects to reliably avoid webbing.¹²

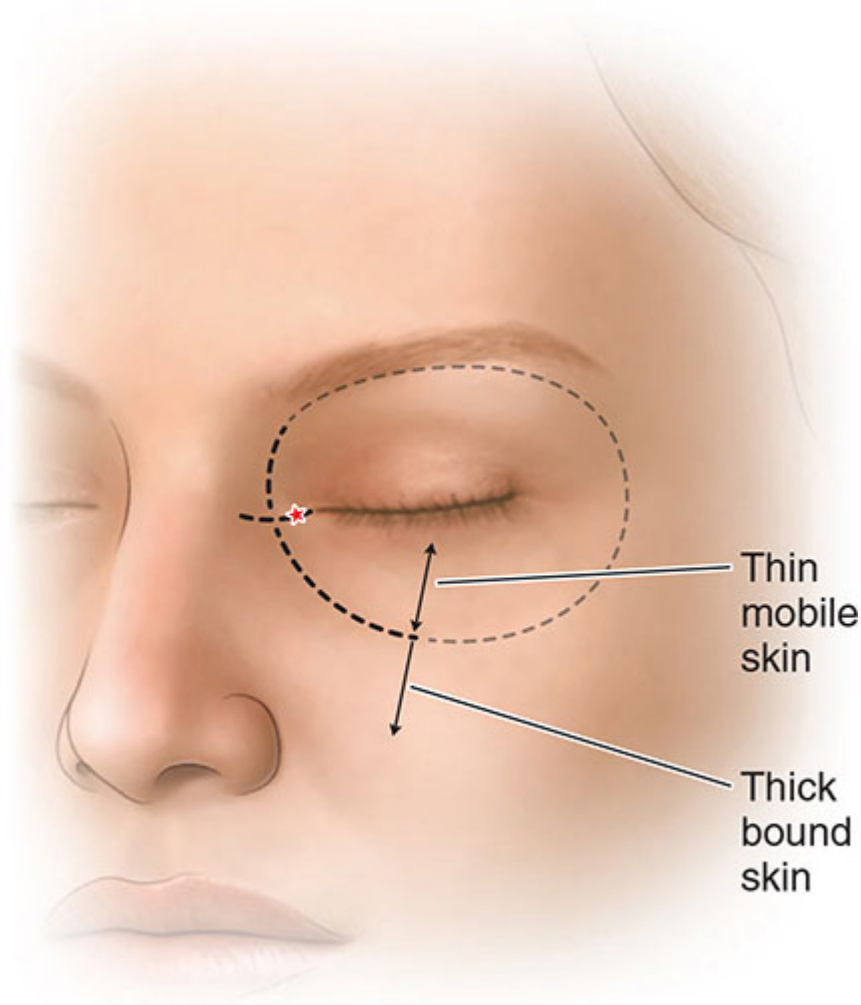


Figure 38-13. Medial canthal subunits: Combining flaps within the canthal subunits and suspending them to the canthal support tissue (*) is a cornerstone of repairing canthal defects to reliably avoid

webbing. Skin inside the orbital rim is thin and mobile compared to thicker bound surrounding skin, easily contracting with tension.

Owing to its innate concavity and complex anatomy, second-intention healing and skin grafting are often used for defects in the medial canthus.^{31–33} Second-intention healing is ideal for small, superficial defects near the apex of the canthus. Full-thickness skin grafts are also commonly used to repair medial canthal defects, and even for deeper defects particularly when tumor surveillance is a high priority.

Nevertheless, flap repairs in the medial canthus often optimize outcomes and help avoid the drawbacks and limitations of grafts and second-intention healing. For defects located at or superior to the canthal apex, hatchet-type rotation flaps based on the glabellar skin are ideal (Fig. 38-14).³⁴ Incisions can be obscured in natural rhytids, and the tissue reservoir is ample, so flaps rotate freely into the canthus. The flap base can provide bulk for deeper defects or can be thinned for superficial defects, and can be easily suspended to the canthal tendon to preserve the natural canthal concavity. The high degree of mobility and minimal visible scarring make this flap a workhorse in this area. Glabellar rotation flaps can be combined with a number of inferiorly based flaps to repair larger defects that include the superior aspect of the medial canthus.³⁵ The canaliculi can be probed and canalized with care not to traumatize them to ensure patency when indicated.²⁸ Damage to the lacrimal drainage system may require reconstructing; however, many patients, particularly elderly patients with dry eyes, benefit from the disruption and do not require repair.

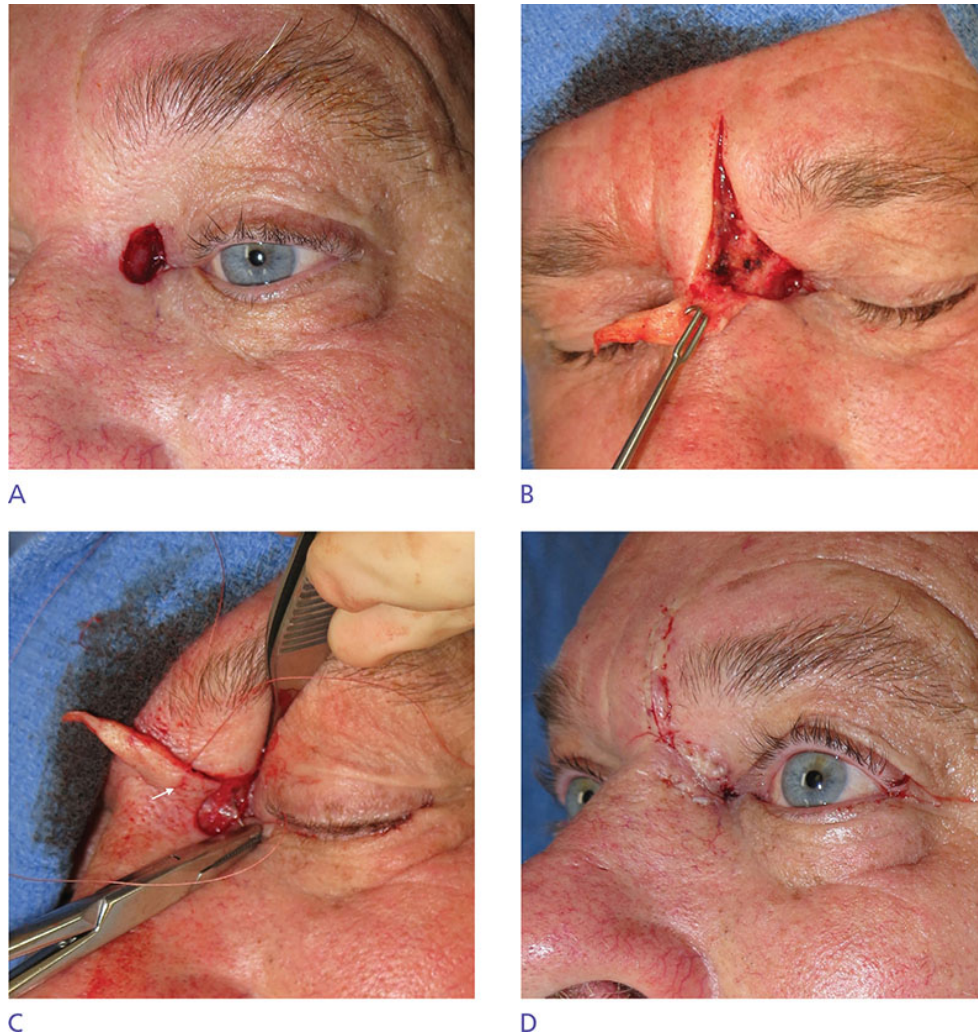


Figure 38-14. Hatchet flap. (A) Medial canthal defect at and above the canthal apex. (B) Flap based on the ample glabellar reservoir undermined in the mid fat with incisions placed in preexisting rhytid. (C) Suspension suture placed in the medial canthal tendon and 1 cm from the flap edge. (D) Canthal concavity preserved with maximal tension postoperatively.

Island pedicle (V–Y type) advancement flaps suspended to the periosteum or canthal tendon can be ideal for superficial and deep defects located at or below the canthal apex, including deeper defects that breach the orbital septum (Fig. 38-15).^{36–41} Incision lines can be partially obscured in the shadow of the nasofacial sulcus, and the medial cheek skin moves readily above the malar fat pad. Island pedicle flaps can be suspended to the periosteum or canthal tendon to preserve the contour of the canthus. Island pedicle flaps are advantageous in this area because they have immense mobility with minimal undermining, do not require removal of redundant

cones, and are easily and efficiently designed and executed. These flaps are best designed with adequate length to avoid webbing, yet slightly undersized width to avoid pin-cushioning. Like blepharoplasty surgery, when the orbital septum is breached, the flap is mobilized and suspended into place without suturing the orbital septum. The septum is left to heal naturally to avoid tethering and lid retraction with wound contraction.

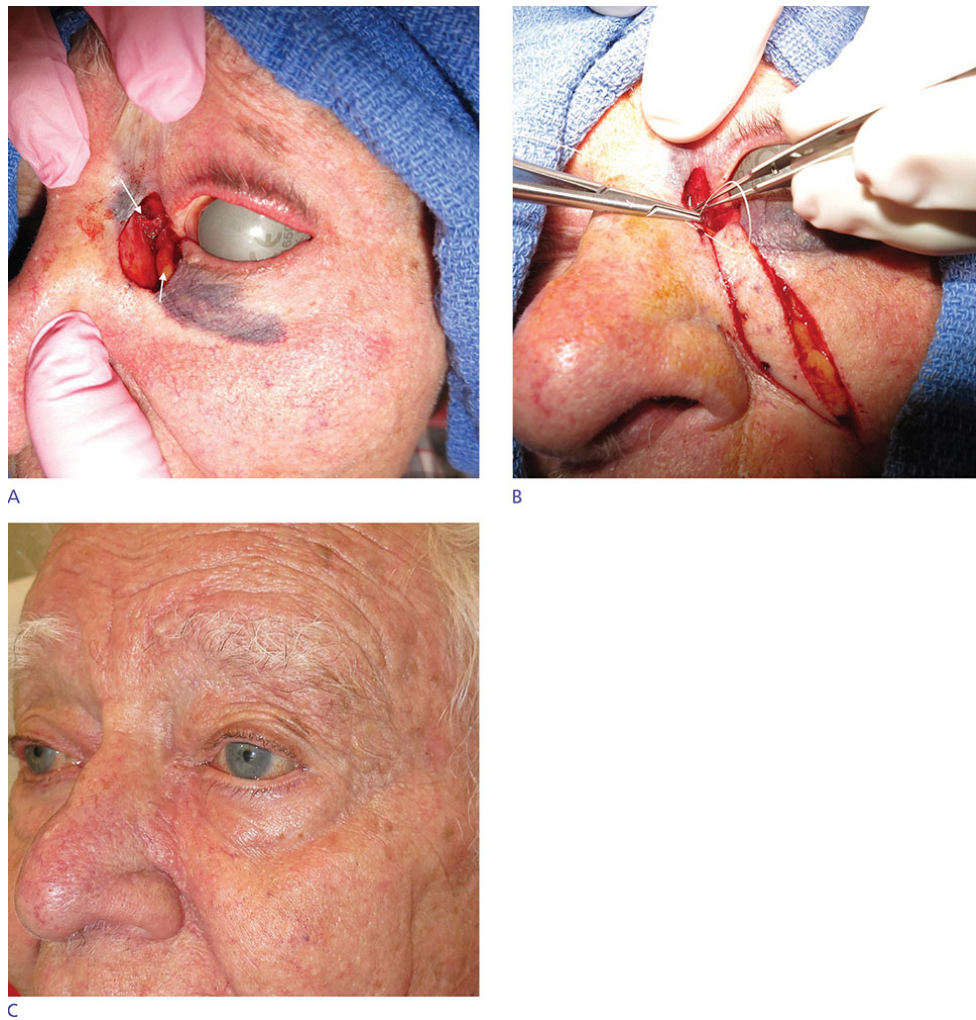


Figure 38-15. IPF with canthal suspension. (A) Medial canthal defect at and below the canthal apex (arrow indicates medial canthal tendon and orbital fat pad). (B) Flap based on the mobile malar fat pad with suspension suture placed in the medial canthal tendon and 1 cm from the flap edge. The orbital septum is left to heal without suturing to prevent tethering. (C) Tension-free flap with concavity preserved and punctum in the lacrimal lake 2 weeks postoperatively.

Larger defects can be repaired with a combination of rotation, transposition, or advancement flaps to avoid webbing. Bilateral rhomboid

transposition flaps that direct redundant cones toward the canthus to avoid webbing are useful for larger medial canthal defects (Fig. 38-16). The largest medial canthal defects may require full-thickness skin grafts from remote sites or two-stage interpolation flaps from the forehead to provide adequate tissue coverage.



Figure 38-16. Double rhomboid flaps. (A) Large defect involving the canthus to the nasal root. (B) Two rhomboid transposition flaps are designed above and below the defects. (C) Well-healed flap without webbing 5 years postoperatively.

For smaller defects close to the lid margins, lid advancement flaps based on lax lid skin are ideal (Fig. 38-17). Incisions are made close to the lash line and advanced horizontally to minimize risk of webbing. Suspension sutures can be useful to support flaps during wound contraction, even for the smallest of defects.

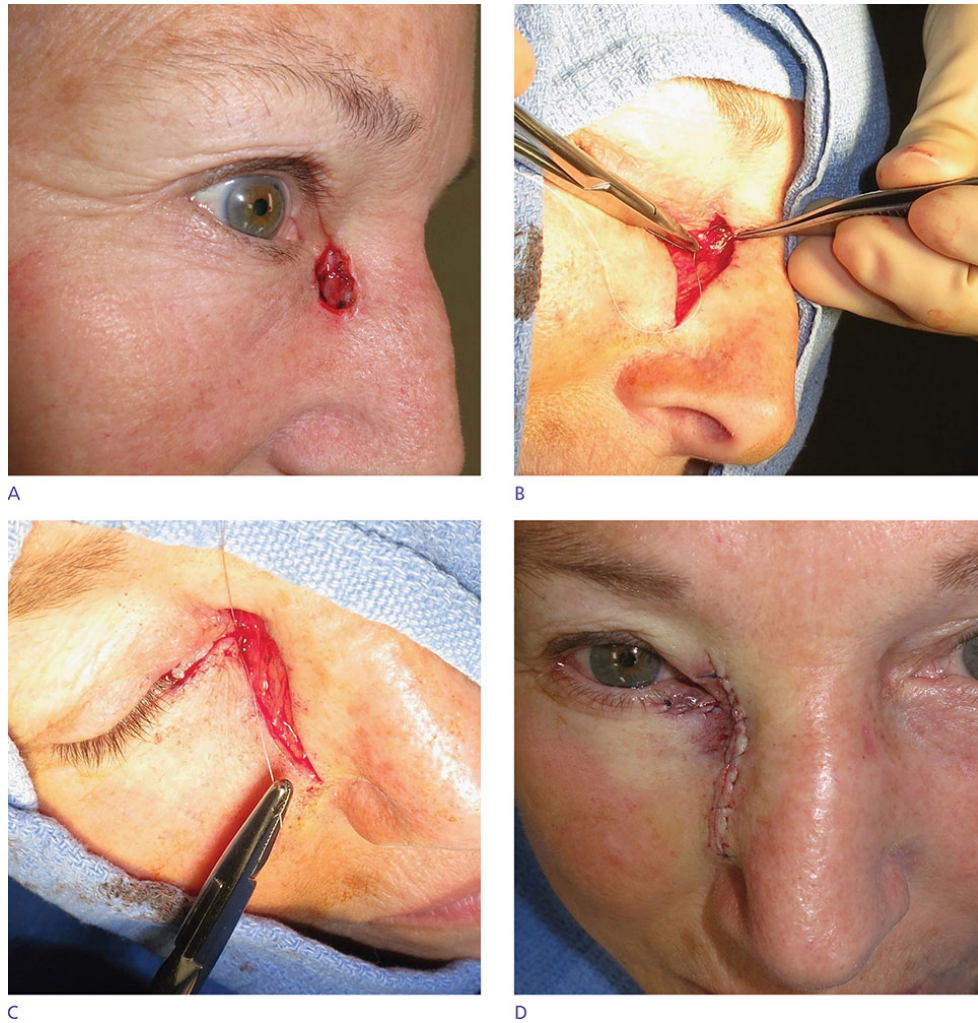


Figure 38-17. Lid advancement flap. (A) Vertically oriented defect below the medial canthal apex. (B) A subciliary incision is made, flap undermined, and suspension suture placed in the medial canthal tendon. (C) Canthal suspension suture is gently tightened with graduated tension. (D) Concavity is preserved with no vertical tension postoperatively.

Suspension sutures can be placed in the periosteum or the medial canthal tendon.^{12–14} An intimate knowledge of the vascular anatomy of the medial canthus and a well-developed tactile sensitivity are essential for precise placement. Suspension sutures are placed through the medial canthus by advancing the needle through the periosteum or canthal tendon, entering and exiting at a shallow angle, and avoiding excessively deep penetration through the underlying lacrimal sac. Flaps are secured at the concavity within the canthus.

FULL-THICKNESS EYELID REPAIRS

Once the full thickness of the eyelid is involved, the reconstructive technique must provide an adequate mucosal surface to replace the missing posterior lamella, as well as the anterior lamella. The conjunctival fornices are generous both medially, and more so laterally, allowing significant central displacement with large wedges that can be reapposed once the lateral canthus and septal attachments are released. For even larger excisions, the tarsal plate and mucosal surface are provided by the release and advance of the upper portion of the inner aspect of the upper eyelid via the supremely versatile Hughes flap. The loss of the medial canthal ligaments and canaliculi, with resultant epiphora, will require a complex multistage reconstruction by oculoplastic and lacrimal surgeons. The primary repair should aim to reconnect the medial edges of the upper and lower lids back together and to draw the reformed medial canthus to the posterior lacrimal crest. The anterior lamella can then be covered with any of the above techniques.

In deciding the best way to reconstruct the tissue lost following tumor extirpation, it is traditional to divide the periocular area involved into subunits and then consider the options for progressively larger defects in that area.

PRIMARY LID REPAIRS: DIAGONAL SUTURE TECHNIQUE

Primary lid repair techniques apply to all full-thickness defects of the lid margin, either alone or in combination with other techniques required for larger defects (Fig. 38-18). Robust and meticulous approximation of the lid margin along the x-, y-, and z-axes is essential to prevent notching and provide the best functional and aesthetic outcomes.⁴² Historically, multiple horizontal tarsal sutures combined with multiple marginal sutures have been used to provide strength and alignment. Because marginal sutures are often bothersome to patients and have the potential to abrade the cornea, a diagonal tarsal suture technique sine marginal suture provides robust strength as well as precise alignment without the need for marginal sutures.^{6,43}

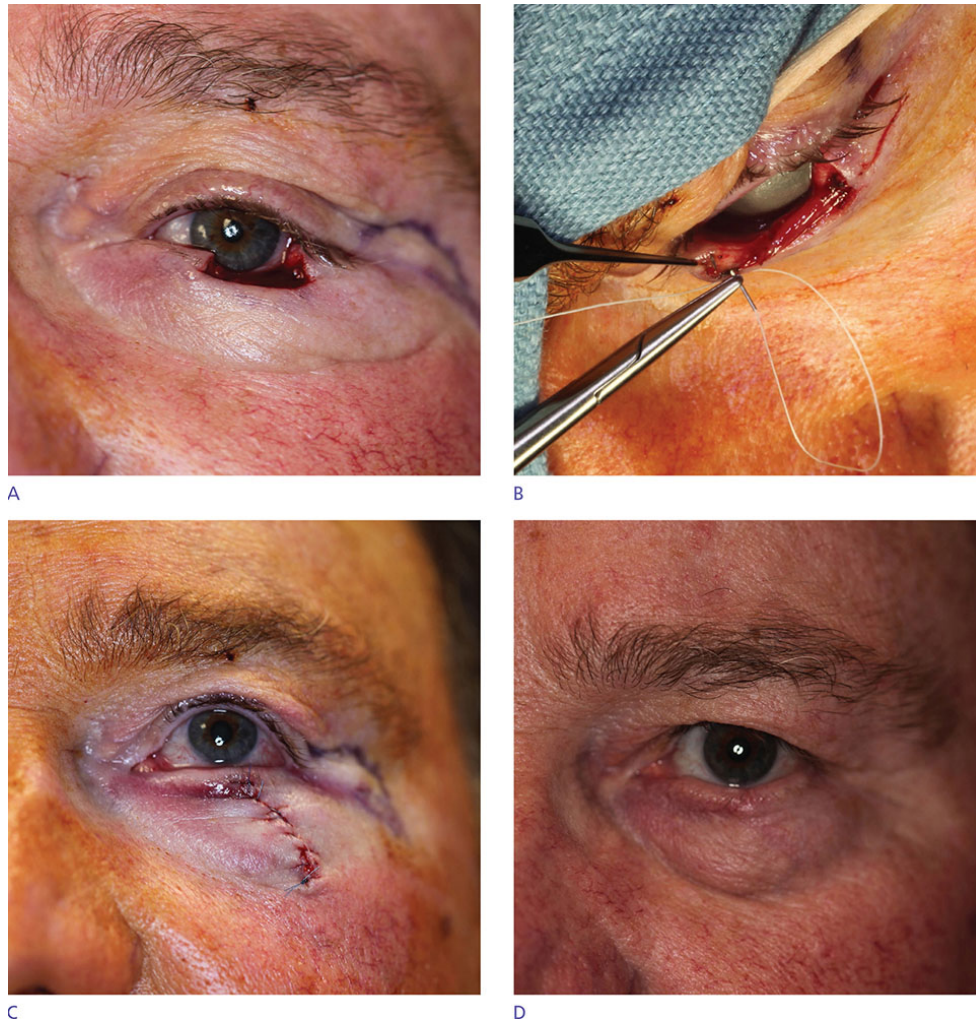


Figure 38-18. Primary lid repair: Diagonal tarsal suture sine marginal sutures. (A,B) Full-thickness defect involving medial the lid margin. (C) Primary lid closure postoperatively, robustly approximated, and accurately aligned without need for marginal sutures. (D) Lid snug against the globe without notching 3 months postoperatively.

To confirm that the tarsal edges can be directly opposed, the medial and lateral ends of the wound are grasped with fine forceps to assess the tension required to bring the edges together. An overlap of 2 to 3 mm should be possible with moderate tension to allow easy closure. If the tension is too great, a lateral canthotomy and cantholysis can be performed to provide mobility of the lid for tension-free closure. For larger defects, the canthotomy may be extended to a Tenzel semicircle rotation flap.²⁶

Technique

Local anesthetic drops are applied to the conjunctival fornix, followed by an injection of local anesthetic containing epinephrine into the conjunctival lid margin, avoiding the marginal arcades.

Before the margin is closed, ensure the opposing tarsal plates have been cut perpendicular to the eyelid margin. This is essential to preserve the curve of the lid margin and avoid distortion or notching. The tarsal plate is recut if necessary.

The tarsal plates are reapposed with two sutures, a diagonal vertical suture and a horizontal inferior suture (Fig. 38-18). Each suture must take a deep bite of the tarsal plate. The superior diagonal suture is passed first into the right-hand tarsal plate 2 mm inferior to the lid margin and 2 mm inside to the cut edge. The tip exits just deep to the conjunctiva at the uppermost aspect of the tarsal plate. This diagonal pass is most easily achieved by grasping the tarsal plate horizontally at its midpoint. The second pass of the superior diagonal suture is into the left-hand tarsal plate. This is most easily achieved by backhanding the suture, grasping the tarsal plate vertically and entering the tarsal plate just deep to the conjunctiva at the uppermost point of the tarsal plate and passing to exit the anterior surface of the tarsal plate 2 mm inferior and 2 mm inside the cut edge. This superior suture is clipped and neither tied nor cut to allow easier access for the next suture. The second horizontal suture is then passed through the tarsus horizontally at the inferior border of the tarsal plate with a generous bite of each tarsal plate, remaining deep to the conjunctiva. This can be tied and cut. The clip from the superior diagonal suture is released and the suture tied and cut. The apposed edges of the lid margin should be in perfect apposition. The closure of the posterior lamella should now be complete. The anterior lamella is then closed in a layered manner with deep sutures closing the orbicularis and skin sutures beginning at the subciliary line. Topical antibiotic ointment is applied to the eye and sutures daily until the skin sutures are removed in 6 days. Ice packs are applied for comfort and to reduce swelling.

LATERAL CANTHOTOMY AND CANTHOLYSIS

Perfect apposition of the lid margin without tension is essential to ensure the lid margin is restored. When the tension on the lid margin exceeds the limits

of a primary lid closure, a lateral canthotomy and cantholysis can be performed to release the lid margin and allow a tension-free closure and prevent notching, torsion, or dehiscence of the eyelid (Fig. 38-19). The limits of a primary closure can be evaluated by approximating the edges of the defect with forceps. Once the cantholysis releases the lid enough to approximate the edges of the lid margin without tension, a primary lid closure can be performed in the usual manner.

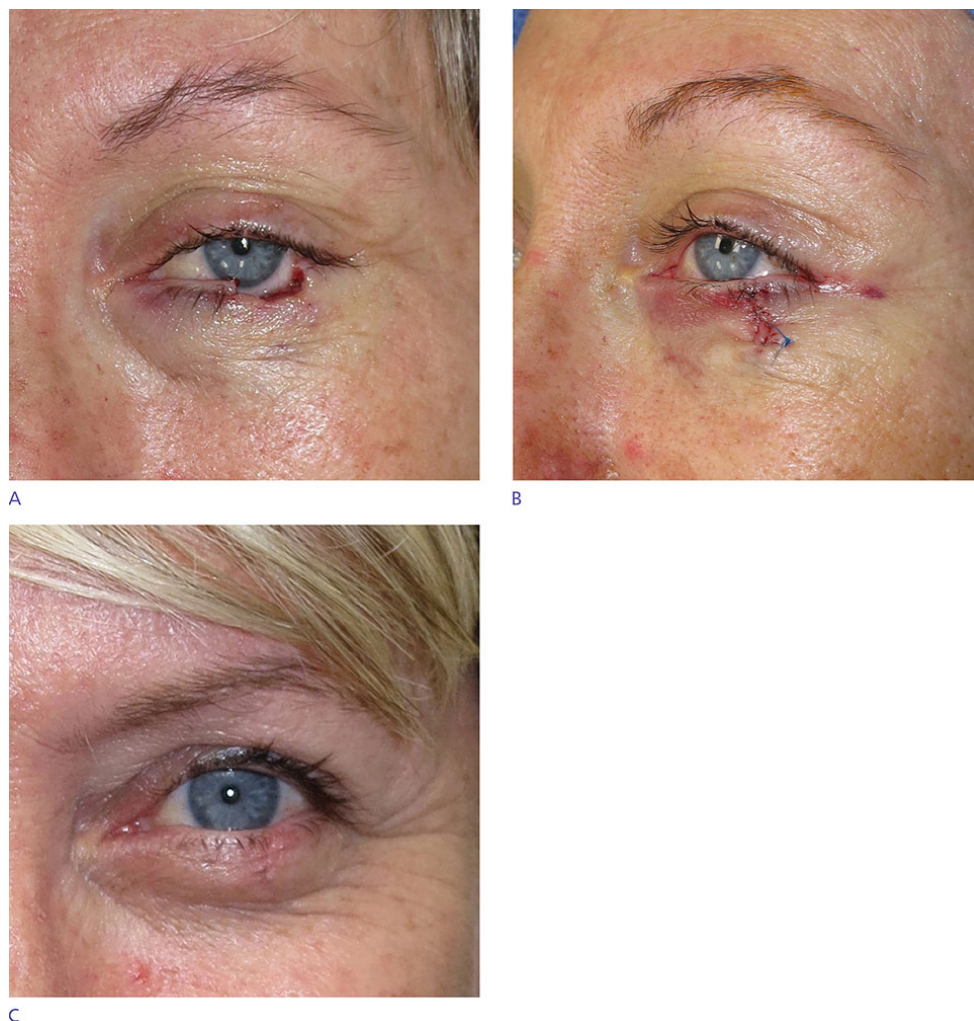


Figure 38-19. Primary lid repair with cantholysis. (A) Full-thickness defect exceeding the limits of primary lid closure. (B) Primary lid closure with lysis of the lower canthal tendon to relieve tension on the wound edges (note the lid margin robustly approximated and accurately aligned without need for marginal sutures). (C) Lid margin precisely aligned without notching 2 weeks postoperatively.

Technique

The incision from the lateral canthal angle is marked to extend laterally and vertically following the curve of the lower eyelid (for upper lid defects, this curve is reversed to follow the upper eyelid). A small primary skin incision is made with a #15 scalpel blade from the angle of the lateral canthus following the markings for 8 mm. Westcott's scissors are used to release the firm lateral canthal attachment of the lower lid with a canthotomy passing through the inferior crus of the lateral canthal tendon. A pocket is made with the scissors on each side of the septum, and then with the lid under medial tension; the tip of the scissors is used to feel for the tight septal fibers by drumming across them. The cantholysis can then be progressively released by making small nibs with the scissors until the wound can be easily closed. An overlap of 2 mm represents perfect tension. The tarsal plate is then closed primarily with a standard diagonal suture technique and the skin and muscle of the primary defects are closed in a layered manner. As the lateral incision is pulled medially, it usually closes automatically and does not usually require a suture.

TENZEL SEMICIRCLE ROTATION FLAP

Full-thickness defects of the lid margin that are too large to repair primarily with a cantholysis procedure can be reconstructed with a semicircle flap described by Richard Tenzel (Fig. 38-20).²⁶ The Tenzel flap combines a modified lateral advancement-rotation flap with canthotomy and cantholysis procedures to repair defects up to 75% of the upper or lower lid margins. The Tenzel semicircle flap is ideally performed when there is at least 2 mm of tarsus remaining, but can be performed successfully with less. There is focal absence of lashes laterally, but this is not a functional concern and rarely bothers patients. Surgeons performing Tenzel flaps should be familiar with canthal anatomy and seek experience and training in more advanced periocular surgery. Defects that are too large to be repaired with a Tenzel semicircular flap are best repaired with a two-stage Hughes tarsoconjunctival flap from the upper lid.⁴⁴

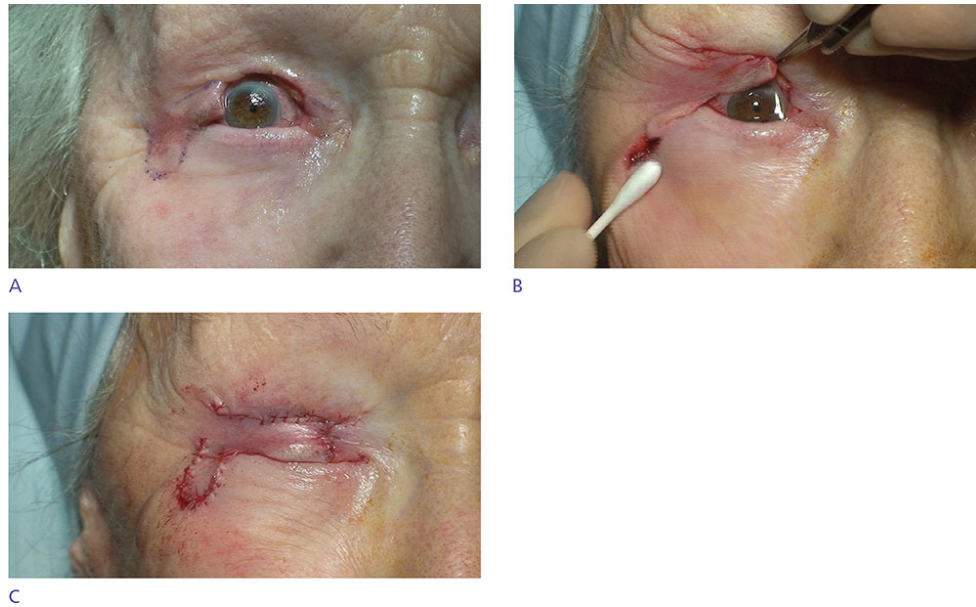


Figure 38-20. Tenzel semicircle flap. (A) Large full-thickness defect involving the upper lid with semicircle rotation flap drawn inferiorly. (B) Semicircle flap incised and rotated to allow closure of the upper lid defect. (C) Semicircle flap and primary lid closure sutured in place postoperatively.

Technique

Incisions are marked from the lateral canthal angle to extend laterally and vertically following the curve of the eyelid. At the apex, the mark begins curving downward forming a semicircle. The average diameter of the semicircle is approximately 1 to 2 cm and in practice may not be a true semicircle. A skin incision is made with a #15 scalpel blade, initially following only the lateral and vertical curves of the Tenzel flap. The flap can be extended later if required. The firm attachment of the lower lid is released with a canthotomy passing through the inferior crus of the lateral canthal tendon with Westcott scissors. The scissors are then used to make a pocket on each side of the septum, and then with the lid under medial tension use the tip of the scissors to feel for the tight septal fibers by drumming across them. The cantholysis is then progressively increased until the wound can be easily closed. Care is taken not to disrupt the upper limb of the canthal tendon. The flap is then rotated and sutured into place and the primary defect closed using the standard diagonal tarsal suture technique. A canthal suspension suture is sometimes placed at the lateral canthus to provide additional support. As the lateral Tenzel flap is pulled medially, it usually closes automatically, and

often only a small number of interrupted sutures are required to close the skin.

POSTOPERATIVE CONSIDERATIONS

Immediately following periocular surgery, erythromycin ophthalmic ointment is applied to the eye and suture line, followed by a light pressure dressing and ice packs for 24 hours to minimize edema. Pressure dressings are applied carefully to wounds so that excessive pressure is not placed on the globe. Defects close to or involving the lid margin are often dressed with an eye pad placed over a closed lid and covered with an eye shield to protect the eye from trauma. Postoperative dressings that are tension bearing can help offset the tension associated with swelling and administration of local anesthetics. Patients are often observed for a period postoperatively before discharge to ensure hemostasis and comfort.

Close observation is essential in the postoperative period to identify potential complications early and ensure success. Patients are instructed to contact their surgeon directly in the case of bleeding or acute pain after surgery. Early recognition and management of serious bleeding is essential to identify and treat potential retrobulbar hemorrhage, which requires an emergency canthotomy to prevent irreversible blindness. Follow-up is generally recommended 24 hours after surgery for complex lid repairs. Complex wounds with full-thickness lid loss that will be transferred to the care of an oculoplastic surgeon may require a temporary tarsorrhaphy to ensure the cornea is protected until definitive repair ([Fig. 38-21](#)).



Figure 38-21. Modified Frost suture: A suture is placed through the meibomian gland orifice of the lower lid margin, following the curve of the needle, and exiting the adjacent lid margin through the meibomian gland orifice. The suture is then secured to the forehead with steri-strips.

TEMPORARY TARSORRHAPHY

Numerous temporary tarsorrhaphy procedures have been described that effectively protect the cornea for a short time period postoperatively. A simple tarsorrhaphy may be performed by passing a 4-0 polypropylene suture through a plastic or petroleum gauze bolster before entering the upper lid, entering 4 mm from the margin and exiting through a meibomian gland orifice. The needle is then passed through the opposing lower lid, entering through a meibomian gland orifice and exiting through the lower lid skin 4 mm or so from the margin. The needle is then passed through the tubing or bolster exiting 1 cm laterally. The needle is then passed through the skin in

the same manner, exiting through the meibomian gland of the lower lid and then through the upper lid and upper bolster in the same manner. The suture is then gently secured to close the lid comfortably.

MODIFIED FROST SUTURE

The Frost suture is a useful technique for opposing downward tension vectors and preserving or restoring the position of the lower eyelid (Fig. 38-21).¹⁸ A 4-0 monofilament suture is passed through the lower lid tarsal plate, entering and exiting the lid margin through the meibomian gland orifice while following the curve of the needle. The suture is then secured to the forehead with steri-strips. The suture may be left in place for up to a week, or slightly longer in the case of ectropion repair. If possible, the Frost suture is placed either medial or lateral to the mid-pupillary line to prevent visualization during natural forward gaze.

COMPLICATIONS

The aim of all techniques is to restore the eyelid without causing distortion or ectropion to the lid margin. Complications can occur even in the best of circumstances. Some common complications include bleeding, infection, hematoma, chemosis, epiphora, dry eye, suture granuloma, trichiasis, lid notching, scleral show, asymmetry, ectropion, and webbing. Even mild ectropion can cause significant epiphora and discomfort and may require a slit-lamp examination to evaluate for corneal abrasion. If this occurs in the immediate perioperative period, a temporary bandage contact lens can sometimes be placed to protect the cornea until offending sutures are removed, or the causative factor is corrected. Complications that occur after wound contraction is complete, such as ectropion or webbing, may require surgical revision. Ectropion and webbing are best prevented with fundamental surgical techniques and tension management, including appropriate flap design, suspension sutures, and Frost sutures when indicated.⁹ Both ectropion and webbing tend to occur 2 to 4 weeks postoperatively during maximal wound contraction. Correction usually requires flap revision and canthopexy procedures. Ideally, patients undergoing extensive surgery around the eye should have a preoperative

ocular examination and consultation with an oculoplastic surgeon to ensure a smooth transition of care if needed.

Ectropion Repair

Simple cicatricial ectropion in the absence of pre-existing lid malposition can be corrected with a flap or graft that lengthens the anterior lamella combined with canthal suspension (Fig. 38-22).⁴⁵⁻⁴⁹ Early intervention is best, before wound contraction is severe. Repair begins with excising the scar and estimating the size of the defect on maximal stretch of the lower lid with upward traction. The defect size can be estimated by blotting the area with a sterile nonadherent gauze pad. The flap or graft can then be appropriately designed to provide ample coverage on maximal stretch. Pushing flaps, such as inferiorly based rhombic transposition flaps or superiorly based Tripier-type transposition flaps combined with a lateral canthopexy, are often straightforward and satisfactory.^{47,48} Full-thickness skin grafts sized adequately with the lid on full stretch, tacked down, and combined with a canthopexy suture or a full lateral tarsal strip are reliable for even some of the most severe ectropion.⁴⁹ A modified Frost suture is generally beneficial to counteract the downward traction and is left in place for 7 to 10 days.

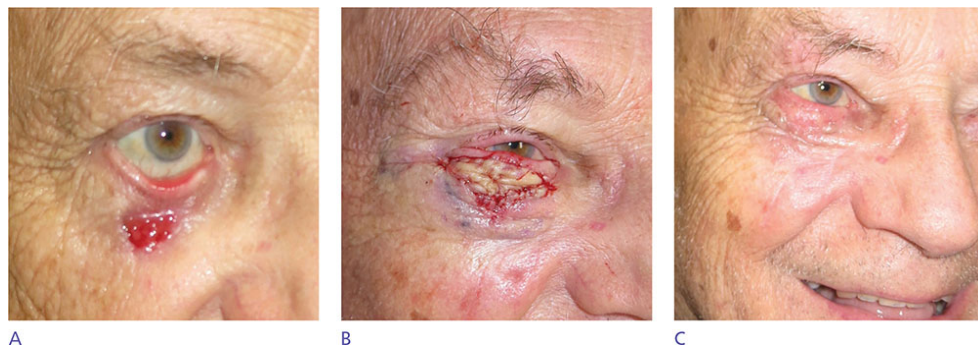


Figure 38-22. Ectropion repair. (A) Low-lid ectropion 3 weeks after the repair was delayed following Mohs surgery. (B) Oversized full-thickness skin graft designed with lid on maximal stretch. (C) Ectropion repaired 2 weeks postoperatively.

Web Repair

Webbing of the medial canthus can usually be repaired with a simple Z-plasty procedure that provides vertical length to constricted skin along the canthal concavity (Fig. 38-23).⁵⁰⁻⁵² Z-plasty repair is performed by incising along the length of the web constriction with a #15 scalpel blade. A 60-degree flap is then created on opposing sides of each end of the incision. The flaps are elevated and transposed to create length, resolving the tensional forces that created the web.

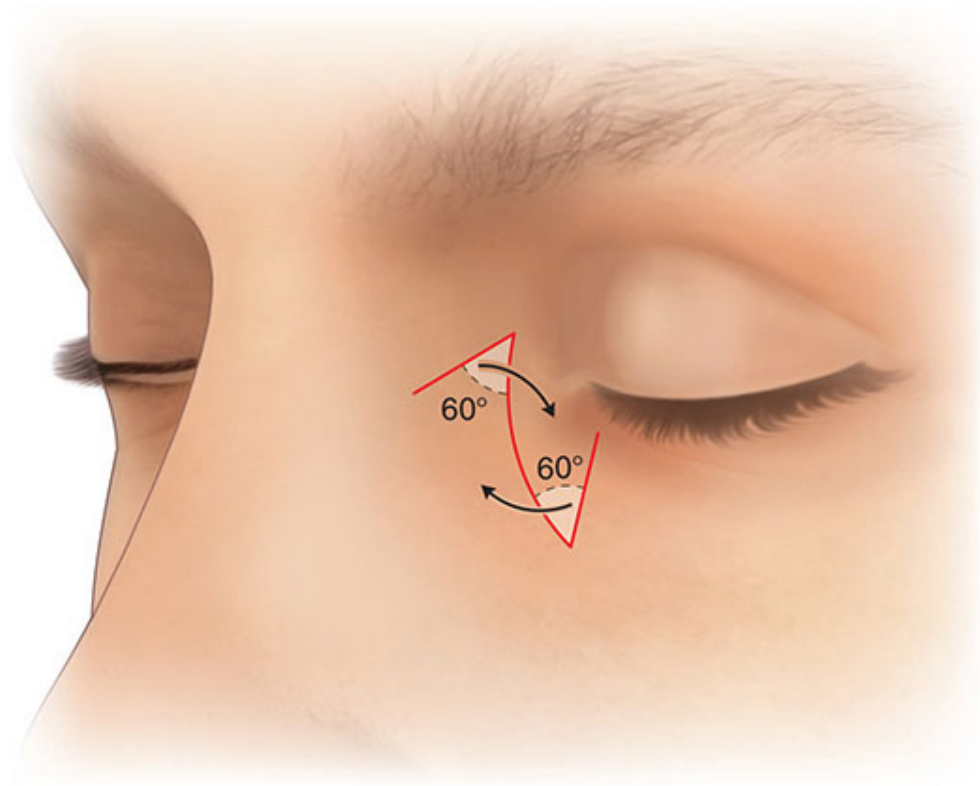


Figure 38-23. Z-plasty repair of canthal web: Z-plasty repair is performed by incising along the length of the web constriction with a #15 scalpel blade. A 60-degree flap is then created on the opposing sides of each end of the incision. The flaps are elevated and transposed to create length, resolving the tensional forces that created the web.

CONCLUSIONS

Eyelid repairs are a cornerstone of dermatologic surgery and reconstruction. Knowledge and familiarity with the management of tension is essential, and maintaining tension parallel to the lid margin is of the utmost importance.

Suspension sutures are used frequently for eyelid reconstruction, and a combination of tailored approaches based on individual anatomy yields consistently outstanding clinical outcomes.

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CHAPTER 39 Reconstruction of the Nose

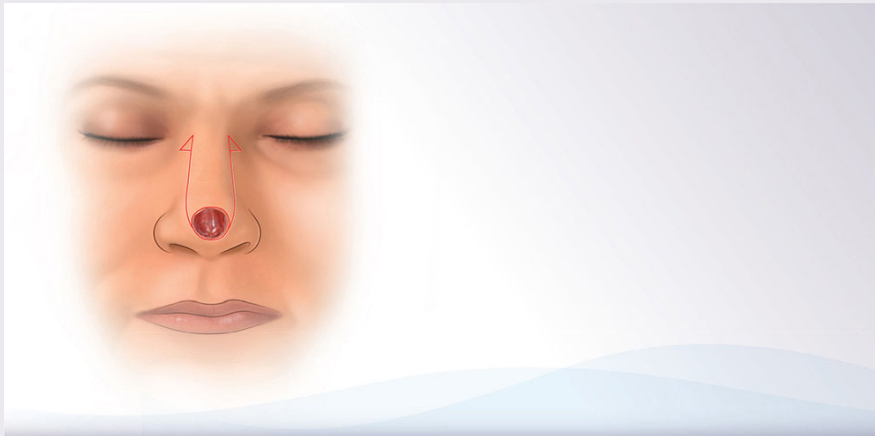
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SUMMARY

- The nose is a focal point of the central face, and subtle changes in shape and contour can easily alter a patient's appearance.

- The task of the surgeon is to simulate normal anatomy by restoring the complex topography of the nose and maintaining patent nasal airways.

Beginner Pearls



- The shape of the nose is usually preserved if tension during reconstruction lies over the immobile bones of the proximal and lateral nose, but may be distorted from tension over the flexible cartilage of the nasal tip or the soft tissue of the alar lobule, which lack cartilage.
- The varying texture and thickness of the nasal skin may influence the selection of donor sites for reconstruction.

Expert Pearls



- The skin is most mobile over the root, dorsum, and sidewalls, where there is a layer of subcutaneous fat separating the skin from the underlying muscles of facial expression.
- The arteries run superficial to the nasal musculature, and therefore undermining flaps deep to muscle at the level of the perichondrium or periosteum preserves the vascular supply.

Don't Forget!



- Placing scars in cosmetic subunit junction lines may help to disguise scars, but reconstruction should prioritize preservation and restoration of free margins and contour.
- For the dorsal nasal flap, advancement of cheek skin is aided by undermining the cheek in the subcutaneous fat.

Pitfalls and Cautions



- The complex nasal topography means that caution should be exerted in not overly evert areas with natural creases, such as the nasofacial sulcus and alar groove.
- When recreating the alar groove, inverting sutures or allowing select areas to heal by secondary intention may be helpful.

Patient Education Points



- The complexity of a closure, and the projected intensity of postoperative care, should be considered carefully, particularly in patients with multiple comorbidities.
- The range of options for surgical reconstruction should be addressed with the patient prior to surgical intervention.

Billing Pearls



- Linear closures on the nose are coded using standard repair series.
- Single-stage random-pattern nasal flaps are coded using 14060 or 14061, depending on the flap size.
- The use of suspension sutures may justify coding a linear closure as complex.

CHAPTER 39 Reconstruction of the Nose

INTRODUCTION

The nose is a focal point of the central face, and subtle changes in shape and contour can easily alter a patient's appearance. The task of the surgeon is to simulate normal anatomy by restoring the complex topography of the nose and maintaining patent nasal airways. Several key principles underlie nasal reconstruction.

ANATOMICAL PRINCIPLES

The distal nose is vulnerable to compression

The bony nasal skeleton resists compression, whereas the cartilaginous skeleton and ala may not. Therefore, the shape of the nose is usually preserved if tension during reconstruction lies over the immobile bones of the proximal and lateral nose, but may be distorted from tension over the flexible cartilage of the nasal tip or the soft tissue of the alar lobule, which lacks cartilage (Figs. 39-1 and 39-2).

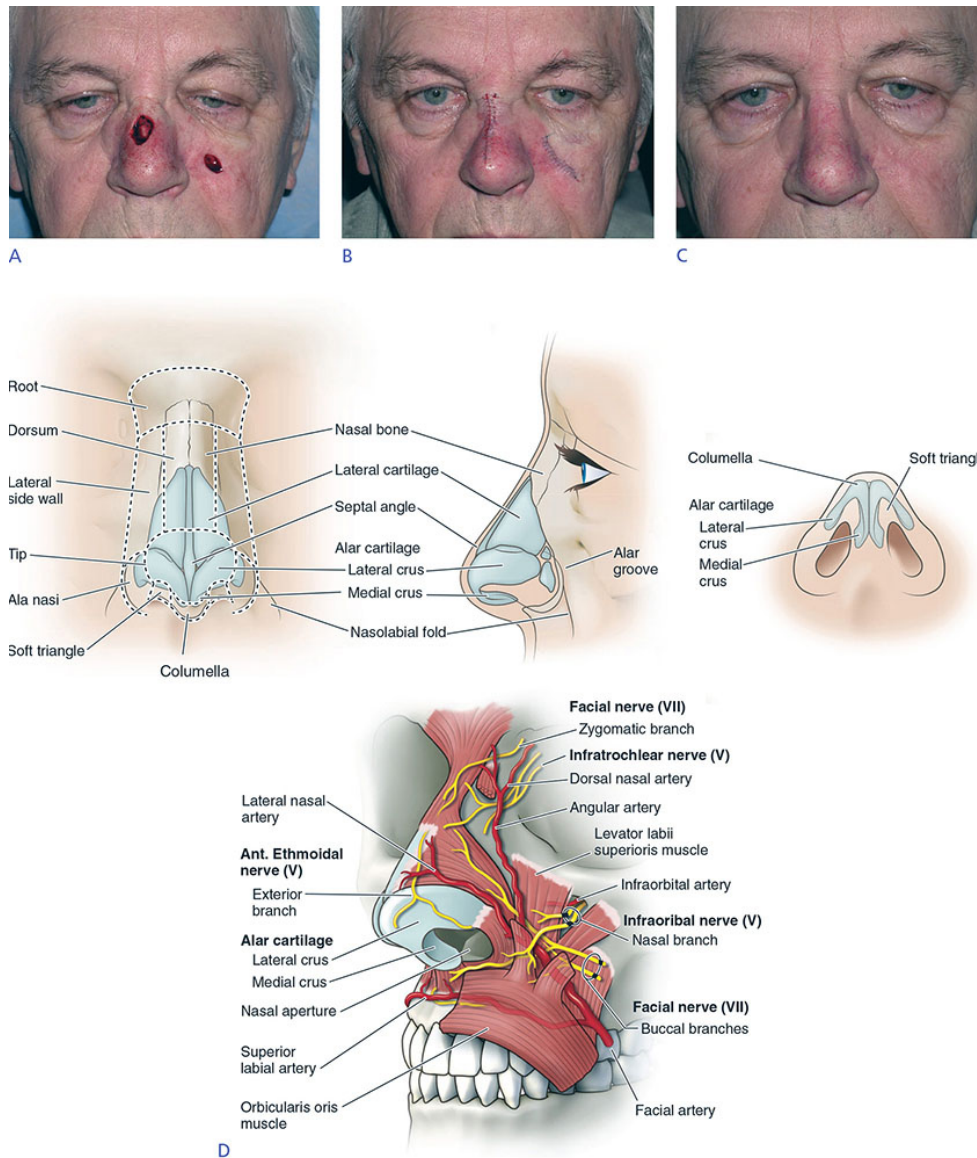


Figure 39-1. The nasal bone resists compression from tension on the proximal nose, but the mobile cartilages of the distal nose may not. A defect of the proximal nose is reconstructed with a tight linear closure. The nasal bone resists compression, and the shape of the nose is unchanged. (A) Mohs defect. (B) Linear closure. (C) Postoperative appearance with preserved nasal contours. (D) Critical anatomy for nasal reconstruction.



Figure 39-2. Tension over the distal nose can compress and distort the nose. Clockwise from top left: Mohs defect; appearance of columella and nostrils prior to reconstruction; compression of the lateral crus of the left lower cartilage and rightward deviation of the septum; primary closure of nasal wound.

The paired nasal bones brace the proximal dorsum and root of the nose, and the maxillary bones gird the nasal sidewall and sill. These bones converge to form the pyriform aperture, which provides a stable frame for the flexible cartilaginous skeleton and anchors most of the nasal muscles of facial expression. The external nasal skeleton consists of three primary cartilaginous structures: (1) the septal cartilage; (2) the paired upper lateral cartilages; and (3) the paired lower lateral cartilages.

The septal cartilage determines the projection and rotation of the nose, separates the right and left nasal cavities, and forms the medial boundary of the internal and external nasal valves. Surgical removal of the distal septal

cartilage or compression during reconstruction decreases nasal projection. Lateral deviation of the septum from undesirable tension vectors during reconstructive surgery can constrict the nasal valves and compromise breathing.

The paired upper lateral cartilages support the lateral nasal sidewall. Their caudal margin forms the lateral border of the internal nasal valve, so airway compromise may occur with the removal or compression of the upper lateral cartilage. The septal cartilage and paired upper lateral cartilages are anchored to bone and are therefore relatively resistant to compression.

By contrast, the lower lateral cartilages do not articulate directly with bone and are vulnerable to compressive forces. Compression of the lower lateral cartilages, which provide structure and projection to the nasal tip and support to the external nasal valve, affects the shape of the nasal tip and can compromise breathing.

The topography of the nose creates shadows and reflections that delineate cosmetic subunits

The nasal surface transmits the shapes of the underlying osseocartilaginous skeleton and soft tissues, resulting in shadows and reflections that divide the nose into the following cosmetic subunits: the tip, dorsum, root, sidewalls, alae, and soft triangles.¹ Scars at the junctions of these cosmetic subunits are frequently less conspicuous (Fig. 39-3). The naturally occurring concavities on the nose are the slight break at the supra-tip (corresponding to the scroll region, where the lower lateral cartilages connect with the upper lateral cartilages); the alar groove (corresponding to the inferior margin of the lateral crus of the lower lateral cartilage and the underlying nasal muscles); the faint shadow at the soft triangles (corresponding to the soft tissue distal to the caudal margin of the domes of the alar cartilages); and, occasionally, minimal bifidity of the nasal tip (corresponding to the space between the domes of the lower lateral cartilages). Naturally convex surfaces on the nose are the alar lobule, the nasal tip, and the dorsal nasal ridges. The dorsum and sidewalls have largely planar surfaces.



Figure 39-3. Scars in cosmetic subunit junction lines are inconspicuous. (A) Melanoma *in situ* of the left nasal tip. (B) The defect has been enlarged to include the entire nasal tip subunit. (C) Reconstruction with a paramedian forehead flap. (D) Postoperative appearance with inconspicuous scars in cosmetic subunit junction lines.

Nasal skin has varying thickness, texture, and mobility

The varying texture and thickness of the nasal skin may influence the selection of donor sites for reconstruction. The dorsum, sidewalls, columella, and soft triangles have a thin dermis and a relatively lower density of sebaceous glands. Skin grafts often heal with a reasonable texture match in these locations. By contrast, the thick and sebaceous skin of the tip, alae, and root is often best replaced by more densely sebaceous skin of the forehead and nasolabial folds, if rearrangement of skin immediately adjacent to the defect is not possible. The skin is most mobile over the root, dorsum, and sidewalls, where there is a layer of subcutaneous fat separating the skin from the underlying muscles of facial expression.

The external and internal nasal valves control airflow and must be preserved or restored

Eighty-five percent of the adult population preferentially breathes through the nose, except in times of exercise or when speaking.² The external and internal nasal valves regulate airflow and resistance, and they are vulnerable to collapse from excessive tension or compression during nasal reconstruction or from loss of integrity during oncologic resection.

The external nasal valve controls air passage through the distal nostril. The anatomic boundaries of the external nasal valve are the caudal edge of the upper lateral cartilage superolaterally, the nasal ala and attachment of the lateral crus laterally, the caudal septum and columella medially, and the nasal sill inferiorly.³ Patients who have a highly flexible nasal tip, whose ala collapses with forced inspiration, or who have improved breathing while distracting the ala laterally (Cottle test) are at particularly high risk for external valve collapse.

The internal nasal valve is located immediately superior to the external nasal valve and is the site of the greatest resistance in the human airway. The internal nasal valve is the flow-limiting segment of the nasal airway and contributes approximately 50% of the total airflow resistance for the combined upper and lower airways.² The internal nasal valve is the cross-sectional area bordered by the cartilaginous septum, the caudal margin of the upper lateral cartilage, and the anterior head of the inferior turbinate. The valve angle between the septal cartilage and caudal margin of the upper lateral cartilage is between 10 and 15 degrees in the Caucasian nose, but

tends to be more obtuse and increasingly resistant to collapse in African-American and Asian noses.⁴ During nasal reconstruction, the internal nasal valve is at risk for collapse from deviation of the septum or from compression or weakening of the caudal margin of the upper lateral cartilage.

The nasal skin has a rich and anastomotic arterial blood supply from both the external and internal carotid systems

The facial artery, stemming from the external carotid system, issues the inferior alar artery along the nasal sill, the lateral nasal artery 2 to 3 mm superior to the alar groove, and the angular artery along the nasofacial sulcus. The columella receives its blood supply from paired arteries that branch off the superior labial artery.⁵ The internal carotid system supplies the nasal skin with the dorsal nasal artery (DNA), a terminal branch of the ophthalmic artery.⁵ The external and internal carotid systems communicate where the angular artery anastomoses with the DNA at the medial canthus and where the lateral nasal artery anastomoses with the DNA at the nasal supra-tip. The arteries run superficial to the nasal musculature, and therefore undermining flaps deep to muscle at the level of the perichondrium or periosteum preserves the vascular supply.⁶

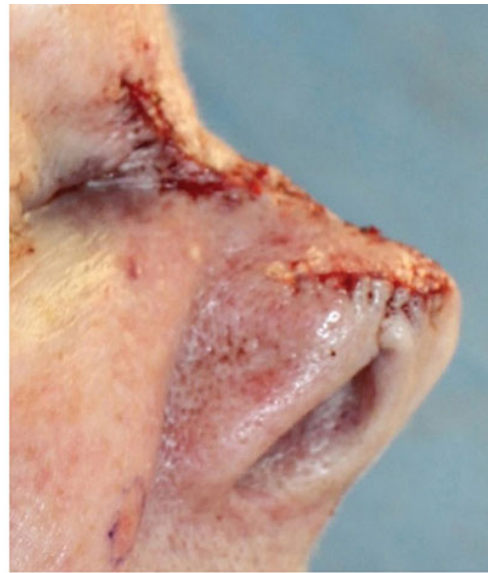
PRINCIPLES OF RECONSTRUCTIVE DESIGN

In descending order of importance, principles of aesthetic surgical design include preserving and restoring free margins and contour, placing scars in cosmetic subunit junction lines, and placing scars along relaxed skin tension lines. The free margins of the nasal tip and ala lack support distally, and so are especially vulnerable to displacement from tension vectors that pull up, push down, or compress (Fig. 39-4). Tension vectors that lie parallel to the free margins minimize upward or downward displacement, and low-tension closures of the distal nose can prevent inward compression. The complex nasal contours can be preserved or restored by avoiding excessive tension over the distal nose, by filling defects with skin of similar volume, and by using tacking sutures to bend skin that crosses nasal concavities (Fig. 39-5).

Placing scars in cosmetic subunit junction lines may help to disguise scars, but reconstruction should prioritize preservation and restoration of free margins and contour. The bilobed and trilobed flaps illustrate this hierarchy. Their clover-like scar, which does not conform to cosmetic subunit junction lines, is inconspicuous if it preserves the position of the free margins and nasal contour. Relaxed skin tension lines are irrelevant on the nose, except for the bunny lines at the upper nasal sidewall and the horizontal crease resulting from contraction of the procerus at the nasal root.



A



B



C



D

Figure 39-4. Displacement of free margins noticeably distorts appearance. (A) Mohs defect. (B) Reconstruction with poorly executed trilobed flap elevates nasal tip. (C) Preoperative position of nasal tip, compared to (D) noticeable postoperative tip elevation.

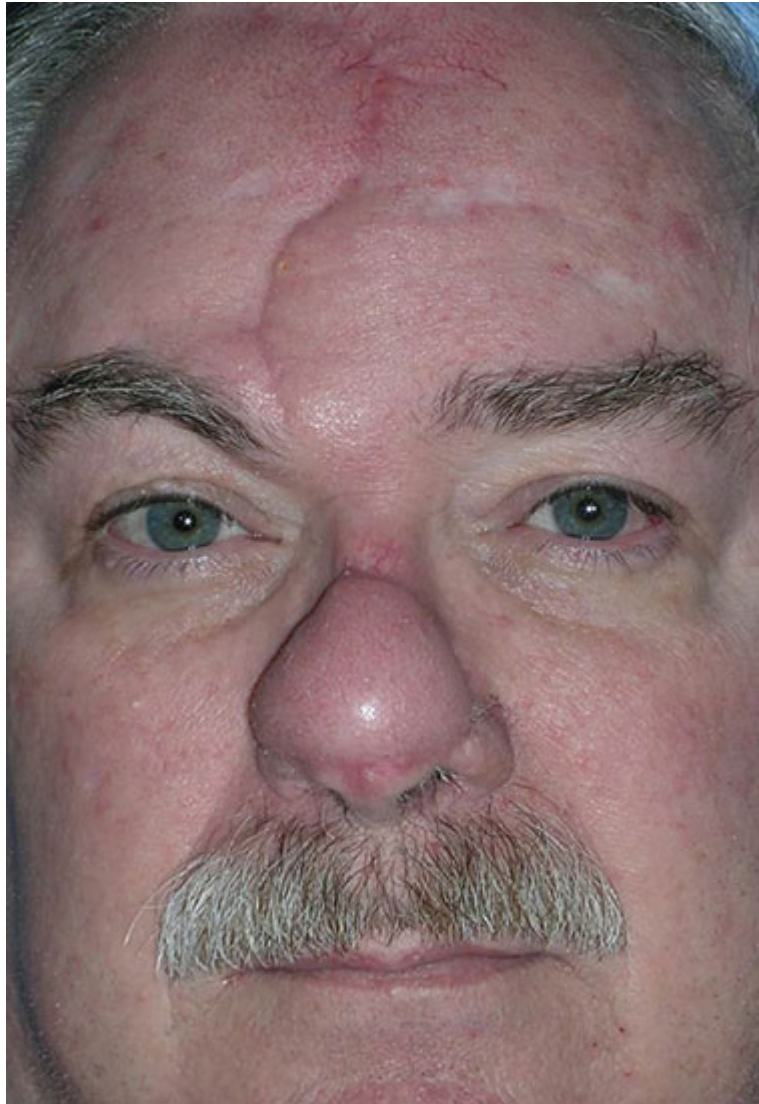


Figure 39-5. Contour deformities of the nose are noticeable. Example of distorted appearance in a patient with excessive volume from flap reconstruction.

SECOND-INTENTION HEALING

Second-intention healing has two predictable outcomes: the scar will have a shiny texture, and the scar will contract. Therefore, ideal wounds for second-intention healing are located in areas where the skin normally has a shiny

texture and where scar contraction will not cause anatomic distortion. The shiny scar from second-intention healing is less conspicuous on the smoother skin of the nasal dorsum, proximal sidewalls, medial canthus, and columella. By contrast, shiny scars may contrast against the more sebaceous skin of the nasal tip, ala, and root (Fig. 39-6).



Figure 39-6. Second-intention scars may be conspicuous on sebaceous skin. (A) A small defect in the middle of the convex alar subunit was left to heal by second intention. (B) The shiny, depressed scar is conspicuous.

Scars formed by second-intention healing may also hide in or recreate concavities, such as the alar groove, the alar insertion, and the medial canthus (Fig. 39-7).^{7,8} However, this strategy must be employed judiciously, since scar contraction may cause anatomic distortion or lead to blunting of a previously pronounced concavity. For example, wound contraction at the alar groove may elevate the free alar margin or result in a webbed scar. Contraction after second-intention healing of wounds of the nasal sidewall and medial canthus may pull on the free eyelid margin or cause webbing from tension on the adjacent, loose eyelid skin.



Figure 39-7. Second-intention healing of wounds in concavities often heals inconspicuously. (A) A shallow wound of the alar groove was left to heal by second intention. (B) The scar hides in the naturally concave alar groove.

The likelihood of anatomic distortion and webbing is greater for deep wounds spanning the concave junction between cosmetic subunits. The ideal defect to minimize distortion from second-intention healing is shallow, with surrounding skin that is stiff and supported by a strong nasal skeleton. Patients should expect evolving color and volume of the scar. Scars that are initially pink and hypertrophic usually mature to a hypo- or hyperpigmented color with a flatter contour.

PRIMARY CLOSURE

Primary closure is a side-to-side approximation of the edges of a wound. Tension lies along a single vector running perpendicular to the long axis of the wound, is greatest at the center, and decreases toward the apices. To minimize standing cones and to maintain normal contour, the ideal angles at the apices of a fusiform excision are <30 degrees, which requires a length:width ratio of 3:1 or greater. The tight, relatively immobile skin of the

distal nose usually requires a length:width ratio of 4:1 or 5:1 (Fig. 39-8).⁹ Assuming proper design, the orientation, location, and tension of fusiform excisions on the nose are the main influences on an aesthetic outcome. The orientation of the fusiform excision determines the direction of the tension vectors. Horizontally oriented fusiform excisions (e.g., in the alar groove) predictably pull up on the free margins, potentially resulting in an upward turn of the nasal tip or alar lift. To avoid malposition of the free margins, fusiform excisions on the nose are best oriented vertically or obliquely, so that tension vectors run parallel to the free margins and avoid an upward pull. Distortion is still possible, particularly on the ala, where elongation of the central axis after wound closure may result in downward push of the free margin.¹⁰

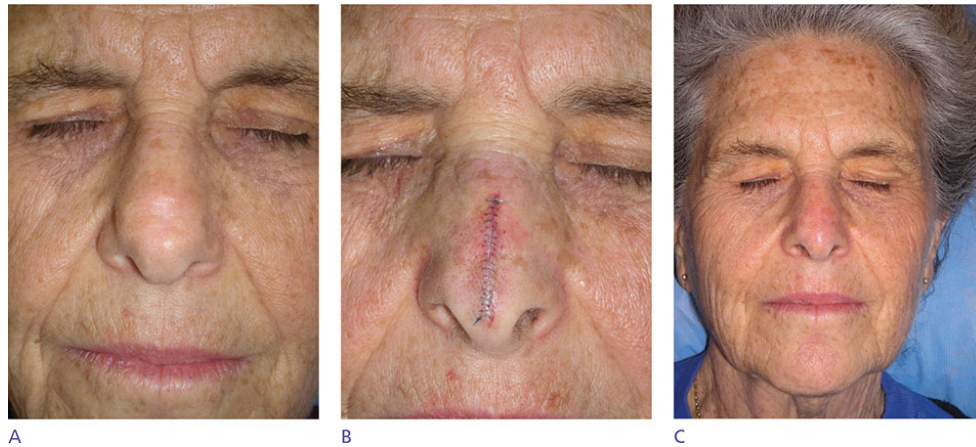


Figure 39-8. Primary closures on the nose often require a length:width ratio of $>4:1$ to avoid preserve contour. (A) Depressed scar of nasal tip with standing cones at each apex from insufficient length:width ratio. (B) The scar was excised and revised with a length:width ratio of $>4:1$. (C) Contour is restored and the scar is less conspicuous.

The tension of a fusiform excision may compress and distort the distal nose. If the center of the fusiform excision (i.e., the area of the highest tension) resides over the proximal and lateral nose, the underlying bones resist compression. However, compression is expected when the greatest tension lies over the nasal tip and ala. Tight closure of vertically oriented fusiform excisions over the distal midline nose (especially if tension is distal to the anterior septal angle) may flatten the nasal tip and cause flaring of the nostrils. Tight wounds on the distal paramedian nose and ala may compress the nostrils and compromise breathing.

The location of the primary closure may determine its effects on nasal symmetry, free margin position, and contour. Vertically oriented closures of the midline tip and dorsum usually cause symmetric changes to each side of the nose. By contrast, high-tension paramidline vertical closures may cause asymmetry from downward displacement of the ipsilateral alar margin and upward pull of the contralateral alar margin. Horizontally oriented fusiform excisions may not pull up on the tip or ala if they are small and located on the proximal dorsum or sidewall and nasal root. Primary closures that cross the concavities of the alar groove or the root of the nose may result in webbed scars that distort contour.

SKIN GRAFTS

Skin grafts lack an intrinsic blood supply, so their survival depends on inosculation with the blood vessels of the wound bed. Thicker skin grafts have a greater metabolic demand and an increased risk for failure. To optimize survival, most skin grafts are harvested with epidermis and dermis but minimal to no subcutaneous fat. Consequently, most skin grafts have sufficient volume to restore contour only for shallow wounds with a base of soft tissue over the perichondrium or periosteum. Skin grafts for deep wounds will result in depressed contour or a skeletonized appearance of the nose (Fig. 39-9).



A



B



C



D

Figure 39-9. Skin grafts usually require soft tissue over the cartilages to preserve nasal contour. (A) Example of skeletonized cartilages from a skin graft without sufficient soft tissue at base of wound. (B–D) Example of preserved nasal contour from a graft with sufficient soft tissue over the lower lateral cartilages.

Donor skin should match as closely as possible the color and texture of nasal skin. The forehead and nasolabial folds have a high density of sebaceous glands, but these sites are used infrequently because of the visibility of the donor scars. Donor sites preferably leave scars in less conspicuous locations. Less noticeable donor sites for smaller nasal grafts include the preauricular skin between the tragus and sideburn, which has small vellus hairs closely simulating the distal nasal skin; the glabellar skin, where a vertically oriented closure may be easily hidden; the postauricular skin, which has a thin dermis that nicely matches the skin of the dorsum and proximal nose; and the conchal bowl, whose stiff and sebaceous skin resembles the skin of the tip and ala. Larger nasal wounds require more generous donor sites, such as the supraclavicular skin, which often has similar actinic damage to the nose.

Grafts may be variably noticeable, depending on the normal texture of an individual's nasal skin. Skin grafts usually are less conspicuous when they replace the thin, nonsebaceous skin of the dorsum, sidewall, and columella (Fig. 39-10). By contrast, grafts are usually readily apparent on thick, densely sebaceous skin of the tip and ala (Fig. 39-11). The density of sebaceous glands varies among individuals, so skin grafts may blend in well for patients with less sebaceous skin.



A



B

Figure 39-10. Skin grafts often have a better match over the less sebaceous regions on the nose. (A) Shallow defect over the less sebaceous dorsum. The wound was repaired with a full-thickness skin graft. (B) Postoperative appearance with relatively inconspicuous graft scar.



Figure 39-11. Grafts on the more sebaceous distal nose are often noticeable.

Full-thickness wounds of the alar margin, soft triangle, and columella may require composite grafts, which contain both skin and cartilage. Composite grafts have an especially high risk for failure, due to their high metabolic demand. As a result, composite grafting is usually limited to wounds less than a centimeter in diameter. The root of the helix is a common donor site for composite grafts.

FLAPS

Advancement Flaps

Advancement flaps have a random-pattern blood supply and are useful for wounds that could be closed with a fusiform excision, except one of the standing cones falls in an unfavorable position. As noted in the section on primary closure, fusiform excisions on the nose usually require a vertical orientation to prevent lifting the free margins. The superior standing cone can usually be excised freely, but the inferior standing cone may encroach upon the margin of the ala and tip. In these instances, an advancement flap maintains tension along the same single vector as the primary closure but displaces the inferior standing cone to a more favorable position at the cheek or columella.

For wounds of the lateral nose, an advancement flap (Burow's flap) may shift the inferior standing cone away from the ala to the nasolabial fold. This unilateral advancement flap is ideal for wounds located entirely superior to the alar groove, because the lateral scar may be completely disguised in the nasolabial fold, and the skin can be advanced with a superomedial vector (Fig. 39-12). If the wound involves the alar groove, a transposition flap is usually preferable, because attempting to advance the cheek skin inferomedially usually lifts the ala. For wounds of the paramidline, an advancement flap may extend the scar medially and shift the inferior standing cone away from the soft triangle to the columella (Fig. 39-13).¹¹



Figure 39-12. Unilateral advancements flaps are useful to repair defects of the nasal sidewall. (A) Mohs defect of the right nasal sidewall. A vertically oriented fusiform repair would encroach on the alar

rim. (B) Immediate postoperative appearance of a unilateral advancement flap. The flap is designed to disguise the horizontal incision in the alar groove, and the inferior standing cone is displaced to the nasolabial fold. (C) Aside from the telangiectasias, the scar is minimally apparent.



Figure 39-13. (A) An “east–west” advancement flap is designed to displace the inferior standing cone to the midline nose during the repair of this tall, paramedian defect. (B) Appearance immediately postoperatively. The wound tension causes temporary alar flare, but the nasal bone and septal cartilage resist compression. (C) Postoperative appearance at 1 week. (D) Longer-term follow-up.

This unilateral advancement flap is limited to small wounds, because excising too much skin from the narrow columella can give the nose a pinched appearance.

Rotation Flaps

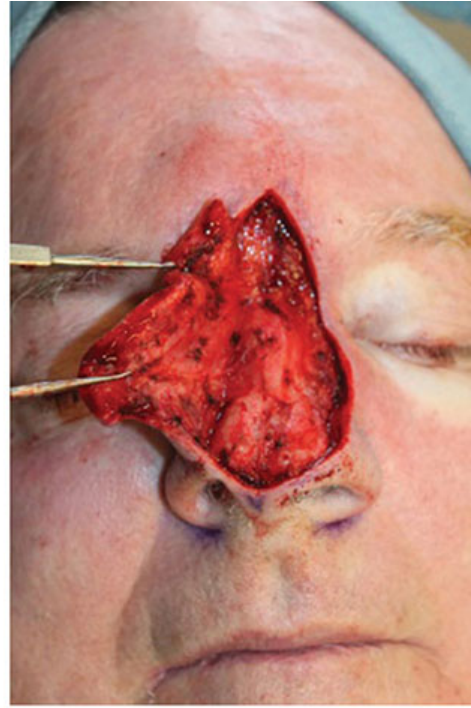
Rotation flaps distribute tension across multiple vectors to avoid the distortion that would occur from the single tension vector of an advancement flap. The hallmark of a rotation flap is the arciform incision used to mobilize the surrounding skin. Rotating the flap into the primary defect creates a secondary defect along the arciform incision. Tension is distributed with multiple vectors along both the primary and secondary defects. Three common nasal rotation flaps include the dorsal nasal rotation flap, the spiral flap, and the Peng flap.

Dorsal nasal rotation flap

The dorsal nasal flap (DNF) is an axial rotation flap based on the DNA (Fig. 39-14).^{6,12} While the DNF may repair full-thickness defects¹³ and alar defects,¹⁴ it is most commonly used to reconstruct partial-thickness defects on the nasal tip or dorsum. The flap recruits skin from more lax areas of the proximal and lateral nose, allowing reconstruction of moderately sized distal defects without nasal distortion. Defects with a longer vertical axis are ideal for the DNF, since the flap's redundant cone also occurs in this direction. Laterally based bilobed flaps may be better suited for distal midline and paramedian nasal defects with a longer horizontal axis.



A



B



C



D

Figure 39-14. Dorsal nasal rotation flap. (A) A dorsal nasal flap is designed to repair this tall, distal nasal defect. (B) Intraoperative photo demonstrating the planes of dissection. The dorsum and tip are elevated superior to the perichondrium. The root and glabella are dissected in the supramuscular plane.

(C) Immediate postoperative appearance. Note the relative preservation of the shape of the nose. (D) The scar is minimally apparent.

The curvilinear arc of the flap takes off from the distal edge of the defect. Taking off from the proximal defect requires excessive advancement of the flap, which may lead to undue tension or nasal tip distortion. The arc sweeps from the distal defect across the lower nasal tip or cephalic border of the soft triangle and alar crease to the nasofacial sulcus, then continues cephalically to the medial canthus and transverse glabellar crease. A back-cut along the contralateral transverse glabellar crease may improve flap mobility, but it should preserve at least 7 mm of skin near the contralateral medial canthal tendon to protect the DNA. If the flap reaches the defect without tension, extension into the glabella is unnecessary.

The flap is elevated in a caudal to cephalic direction. The distal flap over the tip, sidewalls, and dorsum is elevated in the supraprimerichondrial plane deep to the nasalis muscle. At the root of the nose, the dissection shifts to a more superficial plane immediately above the procerus muscle. To improve the mobility of the flap, undermining extends toward the contralateral medial canthus, taking care to maintain the undermining plane just above the periosteum and preserve the DNA.

When the undermined flap slides toward the defect with minimal tension or nasal distortion, the redundant cone is removed. A vertically oriented standing cone decreases the size of the pedicle, but minimizes elevation of the tip and ala. A more horizontally oriented standing cone maximizes the size of the pedicle, but may result in the elevation of the tip or ala. Excising the standing cone to perichondrium will usually transect the lateral nasal artery. If the surgeon fears that the DNA may not supply sufficient blood to the distal flap, the lateral nasal artery may be preserved by excising the standing cone in the subdermal plane. However, the excess soft tissue may result in a bulkier contour.

The key suture for the DNF approximates the leading edge of the flap to the most distal or caudal portion of the defect. Minimal distortion of the nose should occur after placing this suture. The second key suture re-approximates the secondary defect along the nasofacial sulcus. Advancement of cheek skin is aided by undermining the cheek in the subcutaneous fat, immediately superficial to the levator labialis superioris alaeque nasi. Additional sutures are placed along the remainder of the flap, with careful attention to evert the

skin edges, though hypereversion in the nasofacial sulcus should be avoided. If a glabellar incision is made, judicious thinning of the fat and dermis of the glabellar skin to approximate the thickness of the more delicate canthal skin may improve the contour match at the medial canthus. If a glabellar incision is not made, the surgeon may find that a small tissue redundancy may need to be removed by taking a Burow's cone into the canthal area.

Spiral flap

The spiral flap is a rotation flap with a tight arc between 180 and 270 degrees.¹⁵ The flap is ideal for defects of the alar groove and lateral nasal tip (Fig. 39-15). Although the flap has a narrow pedicle and slim distal tip, the robust blood supply from the nearby lateral nasal artery keeps the flap viable.



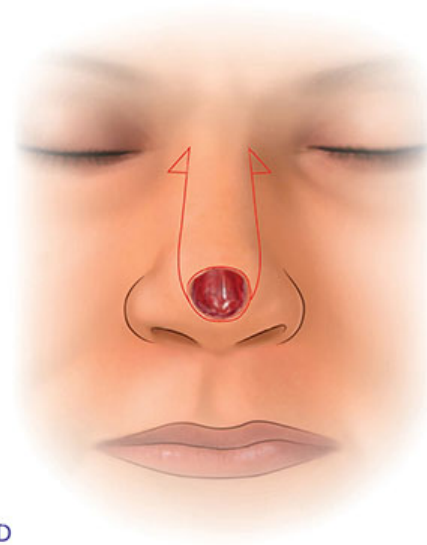
A



B



C



D

Figure 39-15. (A) A spiral flap is designed to repair this small, deep defect of the anterior alar groove. (B) Immediate postoperative appearance. (C) Inconspicuous scar with longer-term follow-up. (D) The Peng flap is a bilateral rotation flap used to repair defects of the nasal tip and distal dorsum.

The take-off point for the arciform incision is at the distal and medial aspects of the nasal defect. The arc extends in a three-quarter circle ending at the nasofacial sulcus. The flap is elevated with or without the transverse nasalis and rotated like a spiral toward the defect. The thin distal tip of the flap bends like a hook to recreate the alar groove. Partial necrosis of the thin distal tip may occur, but second-intention healing along the alar groove still results in a reasonable aesthetic outcome. The secondary defect along the nasal tip and sidewall is sutured with a layered closure.

Peng flap

The Peng flap is a bilateral rotation flap used to repair defects of the nasal tip and distal dorsum (Fig. 39-15D).¹⁶ It can be conceptualized as a bilateral DNF. The take-off points of rotation flaps affect biomechanics: initiating the arciform incision from the distal defect makes the flap tips narrower and more vulnerable to necrosis, but the flaps require minimal distal advancement to reach the distal defect. Pivotal restraint shortens the flaps as they are rotated, so some upward secondary motion from the nasal tip is expected. Initiating the arciform excision from the proximal defect creates a broader flap tip, but the flap requires more distal advancement to cover the defect. Significant secondary motion may elevate the nasal tip.

Regardless of the take-off points, the flaps are rotated centrally and sutured at the midline nose. A standing cone forms at the superior aspect of the defect and requires excision to restore contour. A secondary defect forms along the lateral aspects of the arciform excisions. Closing the secondary defects may result in flaring of the ala or compression of the lateral crura of the lower lateral cartilages, especially if the flaps are used to repair distal nasal defects.

V–Y island pedicle flaps

V–Y island pedicle advancement flaps differ from the other sliding flaps in that their entire blood supply comes from the flap's undersurface (Fig. 39-16). A triangular-shaped flap is designed with the base of the triangle at the edge of the nasal defect. Incisions are made through the dermis of the two remaining limbs, creating the “island” that gives the flap its name. The skin of the nose is relatively adherent to the underlying cartilage and muscles of facial expression, so the flap may not advance after releasing the dermis. In most cases, the underlying muscle must be incised on one of the flap limbs,

and the flap is undermined deep to the muscle.¹⁷ The skin is released from the superficial aspect of the muscle on the opposite limb, and the flap usually gains enough mobility to advance toward the defect. If the flap is still restrained, the muscle pedicle may need to be partially incised. While incising the muscle on both sides of the flap may increase the mobility, it may threaten the viability of the flap.



Figure 39-16. Example of V–Y island pedicle advancement flap. (A) A small, deep defect on the anterior alar groove. (B) The wound is extended in a column to the alar margin, and a V–Y advancement flap is incised in the alar groove and free margin. (C) The flap is advanced anteriorly on its pedicle, leaving a secondary defect along the posterior alar groove. (D) Appearance immediately after surgery. (E) Postoperative appearance with inconspicuous scar and preserved nasal contour.

Once the flap is sufficiently mobilized, a key suture advances the leading edge of the flap toward the defect. Secondary motion is expected, particularly if the flap is still restrained. The secondary defect at the trailing edge of the flap is closed primarily, resulting in a suture line that resembles a “Y.”

To avoid elevation of the tip and ala, the flap is usually designed to recruit skin along a horizontal vector from the nasal sidewall or lateral ala toward the midline. V-Y flaps may also be designed to move from superior to inferior, though elevation of the tip and ala is then more likely.

Transposition Flaps

Transposition flaps avoid distortion and compression of the distal nose by displacing the tension to the tissue reservoirs on the proximal and lateral nose and by keeping tension vectors parallel to the margins of the tip and ala (Fig. 39-17).¹⁸ They are especially useful when tension at the primary defect precludes primary closure or a sliding flap.



Figure 39-17. Tissue reservoirs on or near the nose. The *green circles* highlight tissue reservoirs for transposition flaps of nasal defects.

Three common transposition flaps are the rhombic (single-lobed), bilobed, and trilobed flaps (Fig. 39-17).¹⁸ The latter two flaps have a significant rotational component as well. Adding lobes to the flaps recruits tissue from reservoirs increasingly remote from the primary defect and displaces tension to more favorable vectors. Defects on the proximal nose and sidewall are immediately adjacent to the tissue reservoir, so the single lobe of the rhombic flap may be adequate (Fig. 39-18A). Defects on the supra-tip and proximal nasal tip may require a bilobed flap (Fig. 39-18B), and more distal defects may require a trilobed flap (Fig. 39-18C). In general, the angle between the defect, primary lobe, and secondary lobe dictates whether a trilobed flap is needed, as maintaining acute angles, ideally 45 degrees or less, results in tension-free flap motion.

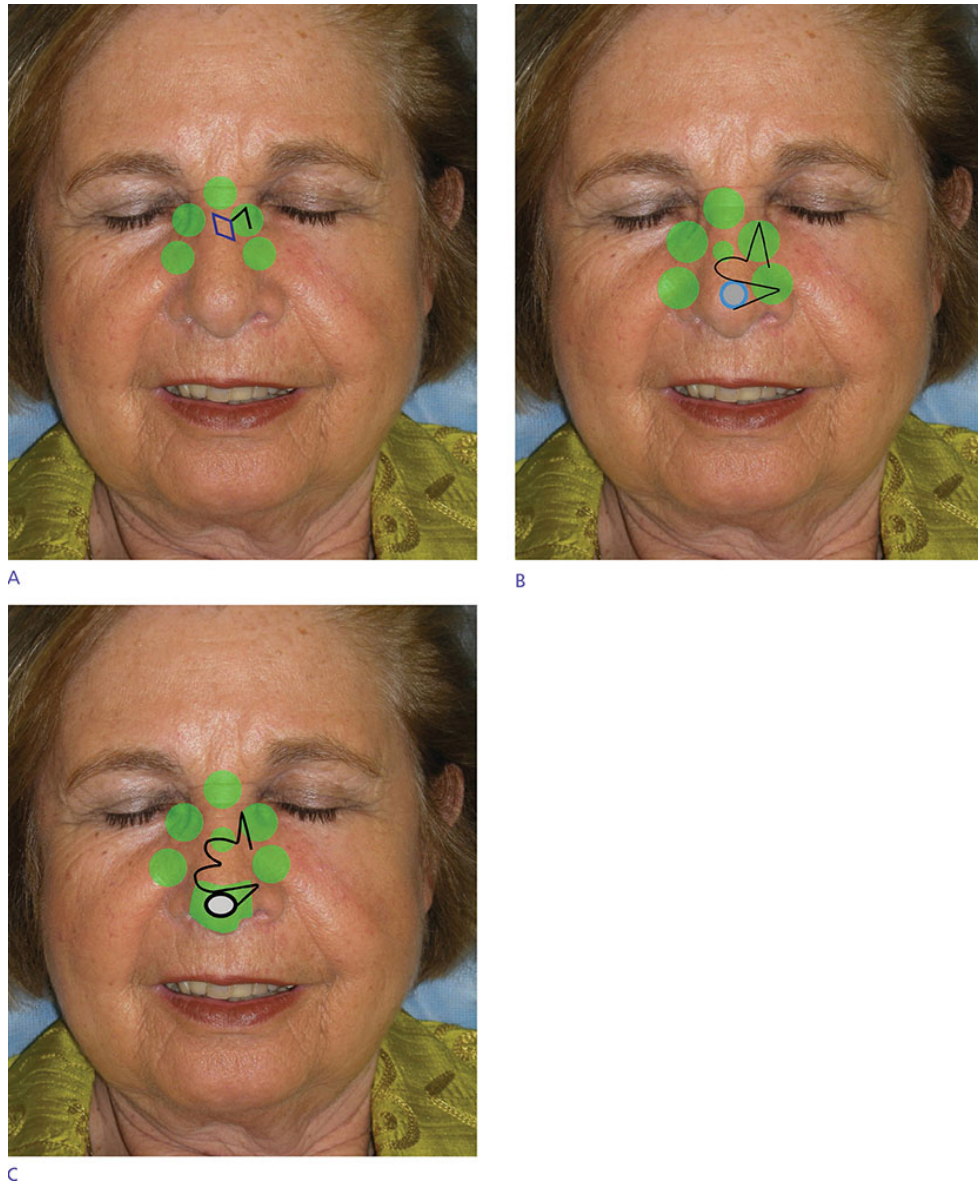


Figure 39-18. Transposition flaps for nasal reconstruction. (A) Rhombic flap. (B) Bilobed flap. (C) Trilobed flap.

As opposed to sliding flaps, which have the greatest tension at the primary defect, transposition flaps displace tension to the ultimate donor site (i.e., secondary defect of a rhombic flap; tertiary defect of a bilobed flap; and quaternary defect of a trilobed flap). By transferring tension to the donor defects over the proximal and lateral nose, the transposition flap can be rotated to the primary defect under minimal tension.

Rhombic transposition flaps

Rhombic flaps are useful to reconstruct smaller defects of the proximal nose and sidewall by recruiting tissue from the nasal root, sidewall, and cheek (Fig. 39-19). The flap extends from the midline of the defect toward the desired tissue reservoir. For nasal defects, the open limb of the flap usually points laterally (i.e., the flap has a laterally based pedicle), which eases closure of the donor site and helps to push the flap toward the defect. The classic rhombic flap has a 60-degree angle at its apex, but lengthening the flap to create a more acute apical angle can facilitate closure and avoid a standing cone deformity at the donor site.



Figure 39-19. Rhombic (single-lobed) transposition flap. (A) A rhombic flap is designed to recruit from the tissue reservoir immediately adjacent to this small defect. Note that the open limb of the flap points laterally. Tissue is recruited from lateral to medial, which pushes the flap toward the primary defect. (B) The flap has been transposed into the primary defect, and the standing cone has been excised along the alar groove. (C,D) At short-term follow-up, the scar is inconspicuous from the lateral and frontal views.

To avoid secondary motion at the primary defect, the flap should have approximately the same surface area as the defect and extend perpendicularly

to the defect.¹⁸ The first key suture closes the secondary defect and bears the greatest amount of tension. The second key suture sets the flap into the primary defect and determines its arc of rotation as well as the position of the standing cone. As the arc of rotation increases, pivotal restraint effectively shortens the flap, making it more difficult for its distal edge to reach the defect, and the standing cone deformity may encroach on the flap pedicle. It is preferable to set the flap so that the standing cone deformity does not narrow the pedicle. Removing the standing cone is often reserved until the flap has been set in its ideal location.

The triangular shape of the distal flap does not correspond to typically circular defects. The surgeon can either trim the flap to match the defect or triangulate the defect to accommodate the flap. Since the distal flap has the most tenuous blood supply, it is usually preferable to trim the excess tissue of the flap to match the defect.

Bilobed flap

If a rhombic flap is not possible because tension on the skin immediately adjacent to the primary defect is excessive or causes anatomic distortion, the bilobed flap can reach donor sites more remote from the defect. The flap is most useful for defects of the nasal tip and supra-tip (Fig. 39-18B). Compared to the rhombic flap, the geometry and execution of the bilobed flap are more complex.¹⁸⁻²¹

Like the rhombic flap, the bilobed flap also rotates approximately 90 degrees (Fig. 39-20). However, the bilobed flap distributes the rotation between the two lobes, each rotating 45 degrees. The second lobe adds a Z-plasty component that helps push the flap toward the primary defect. The tension vector to close the donor site for the secondary lobe (i.e., the tertiary defect) should generally be horizontally oriented (parallel to the alar rim) in order to prevent free margin displacement.



Figure 39-20. Bilobed flap. (A) A laterally based bilobed flap is designed to repair this moderately sized defect of the nasal tip. Note the nearly vertical orientation of the secondary lobe on the nasal dorsum. (B) Immediate postoperative appearance demonstrates preserved position of the free margins of the tip and alae. (C) The nose has good contour and an inconspicuous scar at long-term follow-up.

The first key suture closes the tertiary defect. On the nose, the first suture pushes the flap toward the primary defect more effectively when the final, open limb is positioned laterally (i.e., a laterally based bilobed flap) versus medially (i.e., medially based bilobed flap). The second key suture sets the primary lobe into the defect. The exact position of this suture may vary or require adjustment to create tension vectors that avoid anatomic distortion, to align the standing cone, and to adjust the sizing of the primary lobe. It is often preferable to ensure that closure of the standing cone deformity preserves contour, before trimming excess tissue for a precise fit. The secondary lobe will generally have excess length and require trimming to match the secondary defect.

Trilobed flap

The trilobed flap has tissue mechanics similar to the bilobed flap with a few distinct advantages (Fig. 39-21). First, its third lobe allows the flap to reach tissue reservoirs increasingly remote from the primary defect, and it is particularly useful to reconstruct distal nasal defects. Second, the third lobe extends the arc of rotation to 120 to 150 degrees and may provide a more favorable tension vector to close the quaternary defect. Third, the additional lobe adds the benefit of another Z-plasty, which decreases the tension to transpose the flap, an important advantage when even mild tension at the distal nose can distort the free margins. Finally, the third lobe increases the

width of the flap pedicle. If the orientation of the standing cone would cut into the pedicle of a bilobed flap, the increased pedicle size of a trilobed flap may improve blood supply.²²



Figure 39-21. Trilobed flap. (A) A laterally based trilobed flap is designed to repair a Mohs defect of the lateral nasal tip. The third lobe was necessary to ensure a horizontal (i.e., parallel to the alar rim) tension vector at the quaternary defect. (B) The position of the alar margin is preserved immediately

postoperatively. (C,D) The nasal contour is preserved and the scar is inconspicuous at short-term follow-up.

Nasolabial transposition flap

The nasolabial transposition is a modified rhombic transposition useful to reconstruct defects of the alar groove and ala (Fig. 39-22).²³ The flap recruits tissue from the generous reservoir at the nasolabial fold. Since the alar groove and ala have scant fat, and since the skin is firmly adherent from the dermal insertions of the underlying muscles, this flap can appear too thick and pincushion without precise undermining plane and tacking sutures to recreate the alar groove.



Figure 39-22. Nasolabial transposition flap. (A,B) A nasolabial transposition flap is designed to repair a deep defect that spans the lateral alar groove. (C) Immediate postoperative appearance. The skin is tacked to the pyriform aperture to recreate the alar groove. (D,E) Contour is restored and the scar is minimally apparent at follow-up.

The medial arm of the flap extends from the lateral aspect of the nasal defect down along the nasolabial fold. The lateral arm of the defect extends along the cheek in a parallel line that gently tapers to join the nasolabial fold at its inferior aspect. The horizontal widths of the proximal flap and defect should be identical. The superior aspect of the cheek limb of the flap should remain a couple millimeters inferior to the origination point of the medial limb. This slight discrepancy is important to orient the primary tension vector in a superomedial vector that recruits skin from the mobile buccal cheek.

The flap is elevated to include only the subdermal fat. If it includes the nasolabial fat pad, the flap will have too much volume. The nasolabial fold and cheek are undermined in the same tissue plane.

The key suture closes the donor defect at the flap's origination point. If the wound is under high tension, tacking the cheek to the origin of the transverse nasalis along the pyriform aperture may be necessary to avoid lateral distraction of the nose. The distal portion of the flap is trimmed to match the size of the defect, and it is sutured to the primary defect. The alar groove has a deep concavity, and the flap will pincushion if the dead space is not closed. Tacking the base of the flap to the caudal margin of the transverse nasalis muscle is usually necessary to close dead space and restore contour of the concave alar groove. Transposition of the flap creates a standing cone along the nasal sidewall, which is removed taking care to preserve the flap pedicle.

Interpolation Flaps

Interpolation flaps transfer skin from remote reservoirs with a pedicle that bridges an isthmus of skin between the primary defect and the donor site. The flap pedicle remains intact until the blood vessels at the recipient site grow into and provide sufficient nourishment to the transferred skin. The ingrowth of new vessels is usually reliable after approximately 3 weeks, and the pedicle is divided during a second surgical procedure. Despite the disadvantage of more than one surgical stage, interpolation flaps are

indispensable to repair large nasal defects that exceed the limits of local flaps or skin grafting.

Two interpolation flaps are common for nasal reconstruction. The melolabial interpolation flap (MIF) (cheek-to-nose interpolation flap) recruits skin from the melolabial fold and derives its blood supply from muscle perforators arising from the angular artery. This flap is most useful for defects of the ala, lateral nasal tip, and columella. The paramedian forehead flap recruits skin from the forehead and has an axial blood supply from the supratrochlear artery (STA). As a result of its larger tissue reservoir and more robust blood supply, the paramedian forehead flap is a more versatile flap capable of reconstructing wounds at all nasal locations. For a detailed discussion of interpolation flaps, see [Chapter 26](#).

Melolabial interpolation flap

The MIF, also known as the cheek-to-nose interpolation flap, is a random-pattern flap based upon the muscular perforating arteries branching from the facial, superior labial, and angular arteries in the nasolabial fold area ([Fig. 39-23](#)).²⁴ The primary advantage of this two-staged flap is that it preserves the deep concavity of the alar-facial sulcus, the hairless apical triangle of the upper cutaneous lip, and the narrow isthmus between the melolabial fold and alar lobule. Authors have described multiple variants of the MIF, such as a banner-type flap,²⁵ and an interpolated paranasal flap from the hairless nasofacial sulcus.²⁶ The flap can be used to repair defects of the ala, nasal tip, and columella. This chapter will focus on the traditional design for alar defects ([Fig. 39-24](#)).^{27,28}



Figure 39-23. Trajectory of the facial artery and its perforators. An average of six perforating vessels from the facial artery pierce the overlying SMAS (retracted with forceps). The *black arrows* indicate the level of two of the perforating vessels.



Figure 39-24. Nasolabial interpolation flap and free cartilage graft. (A) A nasolabial interpolation flap is designed for this anterior alar defect. A medially based trilobed flap was also considered. (B) Intraoperative photo showing a free auricular cartilage graft bracing the alar margin. (C) Appearance immediately after interpolation of the flap. (D) Appearance after takedown and inset of the flap pedicle 3 weeks later. (E,F) Follow-up photos show a relatively inconspicuous scar and preservation of the alar groove.

Planning begins with the assessment of the defect. The alar lobule does not contain cartilage, so broad or deep alar defects jeopardize the position of the alar margin. Defects involving more than 50% of the distal alar lobule will usually require free cartilage grafts to brace the ala against scar contraction and to support the airway (Fig. 39-24B). The conchal bowl or the antihelix serve as excellent cartilage donor sites. These cartilage grafts stabilize and preserve the convex shape of the ala, optimizing both cosmesis and function. If the defect involves more than 50% of the alar surface, it may be expanded to include the entire alar subunit. The deep alar-facial sulcus at

the lateral ala is especially difficult to repair, so 1 to 2 mm of the native ala should be preserved in this region whenever possible.

A template is made to match the exact size of the final defect. The melolabial fold is carefully traced with a surgical marking pen (Fig. 39-24A). The template is removed from the nose and rotated approximately 110 to 120 degrees toward the midline and transferred to the melolabial fold. In general, the donor site is located at the midpoint of the melolabial fold between imaginary horizontal lines drawn laterally from the alar sill and labial commissure. Even in men, this location usually does not contain significant terminal hair that would be transplanted to the ala. A rolled gauze may be used to simulate the rotation of the flap and confirm adequate length.

The superior margin of the template will lie directly against the melolabial fold and the anterior margin of the template will be the most inferior portion on the cheek. After ensuring proper orientation, the margins of the template are traced with a surgical marking pen. The fusiform design of the MIF can be completed by drawing the anticipated Burow's triangles inferiorly along the melolabial fold and superiorly toward the nasofacial sulcus. To avoid standing cone deformities, the triangles should be drawn with sufficient length that the angles at the apices of the fusiform design are 30 degrees or less.

The templated portion of the flap is elevated at the junction of the subdermal fat and the nasolabial fat pad. Inclusion of the nasolabial fat pad within the templated portion of the flap will result in excessive thickness and bulky contour. Once the distal 80% to 90% of the templated portion of the flap has been dissected in this superficial plane, the dissection transitions to a plane in the deeper fat, with great care to preserve the perforators. The base of the proximal flap should be at least a finger width in breadth directly over the paranasal perforators just lateral to the ala. This most proximal dissection is performed with blunt scissor tips held parallel to long axis of the flap, spread about 3 to 4 mm apart and strummed or "pawed" with a gentle forward pressing motion. One can feel the plane separating freely. This dissection technique very effectively separates the fibrous septae necessary to loosen the flap while preserving the vessels. The same undermining technique is used to free up the flap at the superior margin and lateral margins, although there are more adherent fibrous connections along the alar crease junction and isthmus that often need some sharp dissection in the immediate subdermal plane above the muscle. Dissection continues until

the flap freely rotates toward the defect without tension or torque. The donor site is closed in a layered fashion to simulate the melolabial fold. The inferior standing cone is excised and discarded.

The margins of the nasal defect are undermined immediately above the lower lateral cartilage or immediately superficial to the vestibular mucosa on the alar lobule. If necessary, a free auricular cartilage graft is sutured to the vestibular lining, and may be tucked into the undermined areas. The flap is transferred to the nose and sutured under minimal tension with a layered closure, except at the alar rim, where only a simple layer of cutaneous sutures is necessary (Fig. 39-24C). Eversion should be avoided along the alar groove.

Three to four weeks later, the pedicle is divided. The base of the flap pedicle is excised as a fusiform ellipse along the superior nasolabial fold and may extend to the nasofacial sulcus. The donor site is repaired with standard layered closure.

The proximal aspect of the flap must be inset at the alar base and lateral alar groove. The proximal flap is elevated from the vestibular lining or free cartilage graft, and the proximal edges of the nasal defect are freshened, and all fibrotic and granulation tissues are excised. The subcutaneous fat and fibrotic tissue are thinned from the base of the flap to match the thickness of the ala. The flap is sutured into the alar crease with simple or layered closure, taking care to avoid eversion and simulate the normal concavity of the alar groove (Fig. 39-24D).

Paramedian forehead flap

The paramedian forehead flap has an axial blood supply based on the STA, though forehead flaps do not need to contain the STA for survival (Fig. 39-25). Planning begins with careful assessment of the defect. Modifying the depth and breadth of the defect can improve contour or help to camouflage scars within cosmetic subunit junction lines. The surgeon must weigh the benefits of defect extension against the risks of airway compromise and added donor site morbidity. Increasing the defect size may make donor site closure more difficult. It also may increase the pedicle length and the likelihood that the donor site will involve hair-bearing scalp. If the defect has missing cartilage, free cartilage grafting may be necessary to restore nasal contour and projection and to stabilize the airway. Full-thickness nasal defects present the greatest challenge, as they require repair of mucosa,

cartilage, and skin. Such defects are most common on the ala and soft triangle and may require a three-staged, rather than a two-staged, forehead flap.^{29,30}



Figure 39-25. Two-staged paramedian forehead flap. (A) A paramedian forehead flap is designed for this large nasal defect. The pedicle is based around the Doppler-identified path of the supratrochlear artery. (B) The flap template is undersized on the proximal nose to avoid a bulky contour. (C) Appearance 3 weeks after the flap inset. The patient is ready for takedown and inset of the flap pedicle. (D) Appearance immediately after a second-stage takedown and inset. Note that the flap has the desired contour. (E) The nasal scar is inconspicuous at follow-up and contour is restored. The patient declined serial excision of the inverted scar on the tight forehead.

Once the final nasal defect has been created, the surgeon must make a template to size the flap. An oversized template will result in a bulky flap. An undersized template will increase tension at the primary wound, potentially distorting the free margins or compressing the distal cartilages. For precise sizing of the template, it is helpful to mold a flexible material,

such as a nonstick gauze or aluminum foil of a suture package, to conform to the exact contours of the defect.

The template is then transferred to the forehead. Determining the side on which to base the flap depends primarily on defect location. For laterally based wounds of the ala, distal sidewall, or hemi-tip, the ipsilateral forehead is usually ideal. Ipsilateral flaps require less length to reach the wound and are therefore less likely to extend into scalp hair. For laterally based wounds of the medial canthus and proximal nasal sidewall, contralateral flaps have less torque and still reach the defect without difficulty. Midline nasal wounds can use either side as the donor site.

After determining the preferred side, the surgeon maps the path of the STA, upon which the flap pedicle will be centered. The most prominent glabellar frown line corresponds to the junction of the medial corrugator and procerus muscles, and can be accentuated by pushing the medial brows inferomedially toward the midline.³¹ The STA is located anywhere from this glabellar frown line to 6 mm laterally.³¹ The path of the STA can be traced with a Doppler probe to identify rare anatomic variations that will not be detected by topographic mapping.

Once the STA is mapped, the surgeon transfers the template to the forehead. To ensure proper orientation, the template is placed on the nasal wound, then rotated 180 degrees toward the side on which the flap will be based. The template is placed in line with the STA so that the portion corresponding to the distal wound lies just inferior to the hairline. If more length is required and the surgeon wishes to avoid transferring scalp hair to the nose, the pedicle can be diverted to the contralateral forehead. Even without an axial blood supply, the distal flap will still have sufficient perfusion via the subdermal plexus.³²

To ensure that the flap will reach the nasal defect, a gauze pad can be stretched from the most proximal part of the pedicle to the distal part of the template near the hairline, and rotation of the flap can be simulated with the gauze. After assuring adequate length, the surgeon can finalize the design. The template is situated at its precise forehead location, and its border outlined, with the proximal pedicle centered on the STA. A pedicle base width of 1.1 to 1.4 cm safely includes the STA and minimizes the increased torque seen with a broad pedicle. The flap's templated portion is usually

wider than its base. To optimize its blood supply, the narrow portion should widen progressively until it meets the templated portion.

The flap is elevated. For two-stage flaps, the thickness of the flap ideally matches the depth of the defect, since aggressive thinning during pedicle division and inset may compromise blood supply. If the incision extends through frontalis or galea before reaching the proximal 10% to 20% of the templated portion of the flap, the flap will usually have excessive volume.

Once the templated portion of the flap is elevated, the dissection proceeds through the frontalis and continues in the plane of the loose connective tissue. A scalpel or blunt-tipped scissors dissect the tissue away from muscle with minimal effort. As the dissection approaches the brow, the surgeon will see yellow fat deep to the corrugator muscle. Cotton-tipped applicators can be used to push away the corrugator muscle fibers without causing bleeding of the superior orbital plexus. Vessels deep to the corrugator are left intact to minimize venous congestion, but can be precisely electrocauterized if necessary. Flap length is assessed by rotating the flap toward the midline, and the dissection stops when it reaches the nasal wound without tension.

If the template has been sized precisely and the flap and defect thickness match, inset should be straightforward. For a two-staged flap, cartilage grafts should be placed prior to inset. The main objectives during flap inset are to align the templated portion with its corresponding nasal defect site. Undermining the defect margins prior to inset may help prevent pincushioning. The distal flap is anchored to the nasal wound; suturing proceeds proximally along its lateral aspects.

The forehead donor site is undermined in the loose connective tissue and closed in three layers, with buried sutures for the frontalis and dermis, and superficial cutaneous sutures if needed. Any area too tight to close primarily maybe left to granulate. Intact frontalis muscle and loose connective tissue under the templated portion of the flap can speed healing. The shiny scar from a wound left to heal by second intention will often be aesthetically acceptable. Efforts to close the forehead site with rotation flaps or grafts lengthen the procedure, increase discomfort, and provide few long-term cosmetic benefits. If the forehead scar is unsatisfactory, serial excisions spaced several months apart will usually permit direct closure.

After the flap is inset and the forehead donor site is closed, the pedicle is inspected for any bleeding. Indirect hemostasis closes larger vessels and precise direct hemostasis controls bleeding of smaller vessels in the

subdermal and dermal plexuses. Failure to control bleeding of the pedicle diverts blood from the distal flap. After careful hemostasis, a hemostatic bandage (e.g., Surgicel®, Puracol®) wrapped gently around the pedicle controls minor oozing. The patient may be prescribed analgesics and antiemetics, which are especially important in patients with tension at the forehead donor site. Postoperative discomfort typically abates after 24 hours.

Three to 4 weeks later, the flap is fully integrated with the nasal blood supply, and the STA is no longer needed for its survival. The patient returns for a second procedure to divide the pedicle and inset the flap. The pedicle is incised. The edges of the proximal nasal defect are freshened and all fibrosis and granulation tissue are removed from the base of the wound. Likewise, the fibrosis and granulation tissue are removed from the undersurface of the proximal flap and the flap is trimmed to match the precise dimensions of the nasal defect. The proximal flap is sutured in a layered fashion.

Attention is then turned to inset the pedicle at the medial brow. If the pedicle base was carried through the brow to increase flap reach, the hairs may have been pulled inferiorly and medially. To maintain symmetry, the surgeon may want to realign them by trimming the flap pedicle in the shape of an upside-down “V.” If inseting the hairs is not necessary, it may be possible to excise the base of the pedicle and repair the wound with a linear closure. Carefully placed dermal sutures promote eversion and minimize pincushioning.

CONCLUSIONS

Key principles of anatomy guide assessment of nasal defects and planning of the reconstruction. When possible, nasal defects can be closed with linear repairs, though given the complex topography of the nose and the multiple free margins that are prone to distortion, even relatively small defects may benefit from flap closures. The complexity of a closure, and the projected intensity of postoperative care, should be considered carefully, particularly in patients with multiple comorbidities. The range of options for surgical reconstruction should be addressed with the patient prior to surgical intervention.

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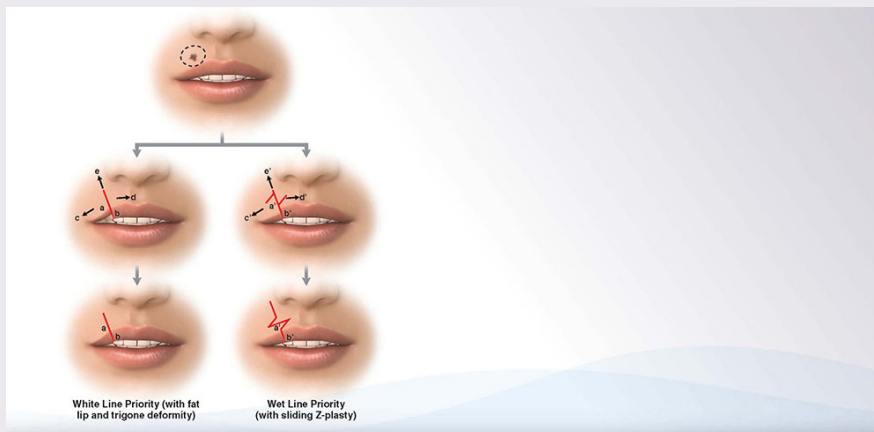
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CHAPTER 40 Reconstruction of the Lips

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Glenn D. Goldman



SUMMARY

- Lip reconstruction has significant aesthetic and functional implications.
- Attention to cosmetic subunits, as well as important landmarks such as the white line, is of paramount importance.
- Linear and wedge repairs are generally most straightforward, though larger defects benefit from a variety of flap approaches.

Beginner Tips



- Small defects on the upper and lower cutaneous lip may be repaired in a linear fashion; aim to orient closures along existing creases if possible.
- Advancement flaps are frequently performed for mid-size defects on the upper cutaneous lip; incise parallel to and 1 mm from the vermillion border for ideal camouflage.

Expert Tips



- While island pedicle flaps have a reputation for undesirable scarring, this can be largely obviated by judicious undermining and meticulous suturing.
- If the nasolabial fold is blunted, Z-plasty can be considered approximately 6 months postoperatively.
- Partial closures may be useful in select patients, particularly those reluctant to undergo larger procedures.

Don't Forget!



- Z-plasty may be useful for the management of trigone deformities.
- Mucosal advancement flaps should be performed with a minimal number of buried sutures.

Pitfalls and Cautions



- The white line in younger patients is very pronounced; deviation of less than 1 mm may still yield a cosmetically obvious mismatch.
- Larger lip reconstructions, such as the Karapandzic flap, must be performed precisely to avoid disastrous outcomes.

Patient Education Points



- Always gauge a patient's willingness to undergo and recover from an extensive procedure *before* it is initiated.
- Some patients may prefer a small partial closure to a more involved and much larger flap.

- Patients should be warned against opening their mouths wide, eating fruit such as apples, and other activities that stretch the orbicularis oris in the immediate postoperative period.

Billing Pearls



- Most flaps on the lips are coded with 14060 or 14061, and these codes include the excisional component; it is not appropriate to bill both an excision and a flap repair code simultaneously, except for Mohs excision codes.
- When coding a flap, graft, or linear repair, medical necessity is the ultimate arbiter of appropriateness.

CHAPTER 40 Reconstruction of the Lips

INTRODUCTION

The lips and perioral region represent a critical region both aesthetically and functionally. They are central to facial expression, are sensory organs for food and personal contact, and provide oral competence at rest and during mastication. The lips also have rich vasculature and sensory innervation.

The perioral region is bounded by the nasolabial folds laterally and superiorly, and by the mental crease of the chin inferiorly. The lips are suspended only by muscles and the fibrous tissues of the modiolus at each oral commissure. Therefore, the lips and the oral commissures represent mobile free margins. Reconstruction of the perioral region requires meticulous planning to direct tension in appropriate vectors. Retraction of the upper lip margin creates the appearance of a hair lip. Midline retraction may simulate a cleft lip repair. Distortion of the lateral oral commissure can lead either to drooling or a permanent sneer. Depression and/or eversion of the lower lip may lead to a loss of oral competence. [Table 40-1](#) reviews many of the complications unique to lip reconstruction ([Figs. 40-1 through 40-20](#)).

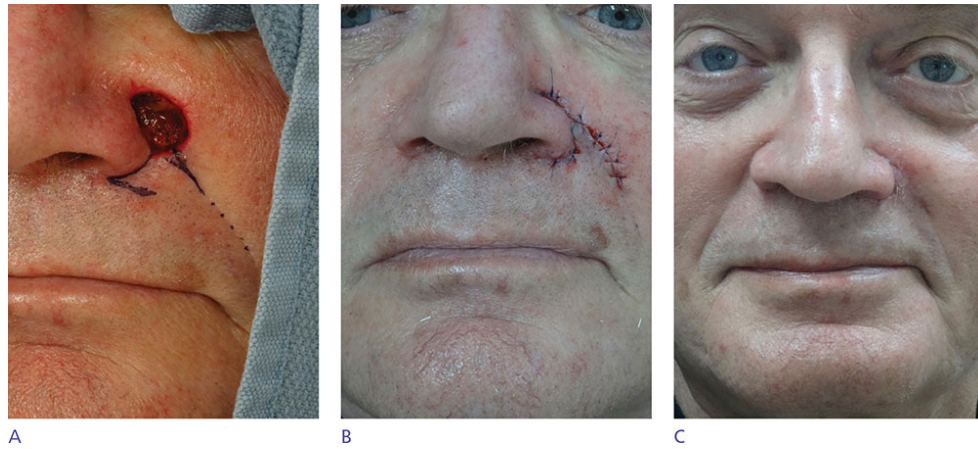


Figure 40-1. (A) Wound involving entire apical triangle. The subalar upper lip is an especially effective donor site to reconstruct the apical triangle. (B) Flap in position. (C) Appearance at suture removal. Apical triangle preserved.



Figure 40-2. Aligning the wet line after the white line (vermillion border) can result in a fat lip deformity.

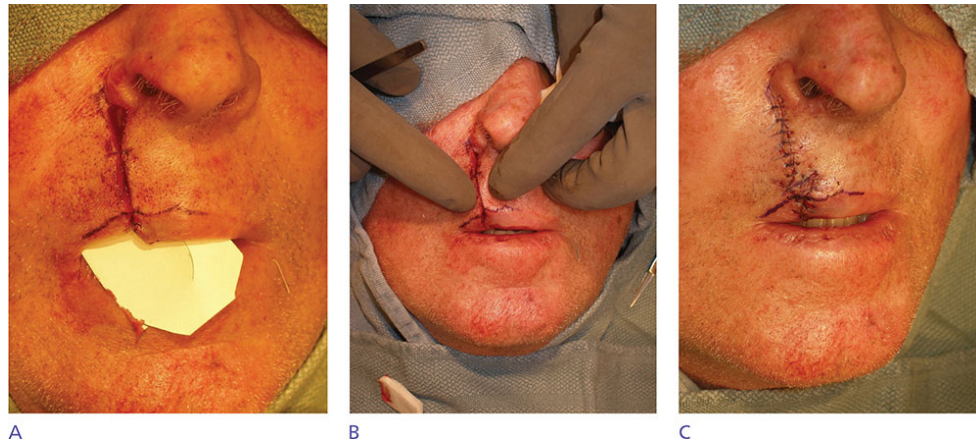


Figure 40-3. (A) Wet line step-off when vermilion border is aligned as first step in reconstruction. (B) Aligning the wet line (instead of the vermilion border) results in a step-off at the vermilion border. (C) A sliding Z-plasty restores vermilion alignment while the wet line prioritized closure averts a fat lip deformity. (Reproduced with permission from Wentzell JM1, Lund JJ: Z-plasty innovations in vertical lip reconstructions, *Dermatol Surg.* 2011 Nov;37(11):1646–1662).

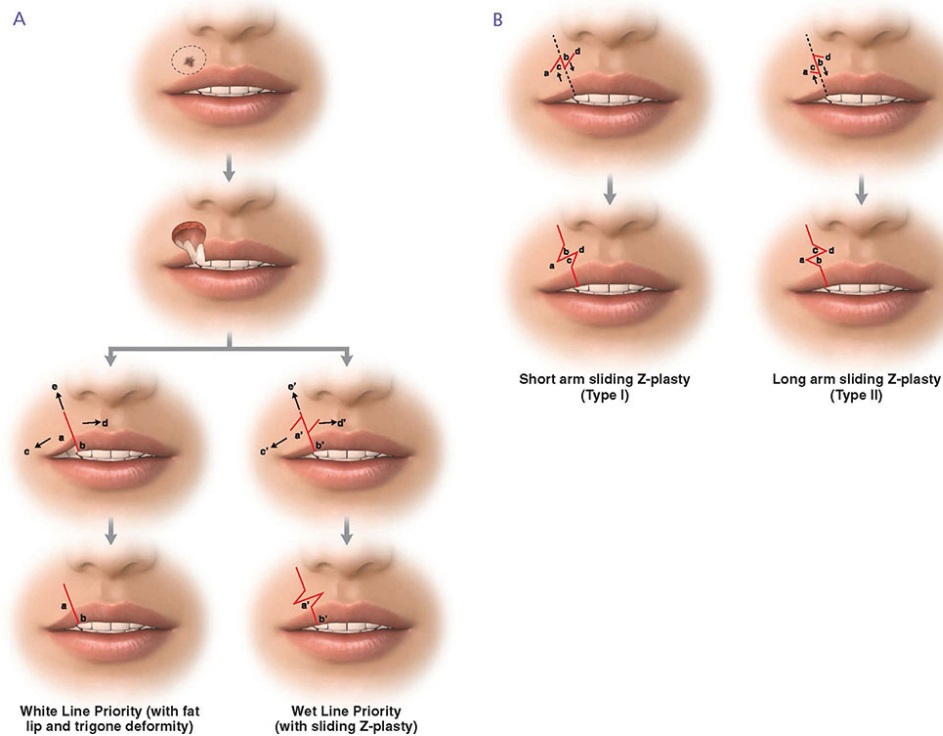


Figure 40-4. (A) In a white line prioritized lip alignment, a wet line step-off and trigone deformity can occur under common conditions. A fat lip deformity can occur with correction of the wet line step-off. In a wet line prioritized alignment, a sliding Z-plasty corrects the white line misalignment. In addition, tension vectors c' , d' , and e' are reduced relative to tension vectors c , d , and e , reducing the source of the trigone deformity. (B) A Z-plasty will “slide” one side relative to the other side if the central limb is not the same length as the side limbs. In practice, the surgeon may elect a short central arm or a long

central arm, but the Z-plasty configuration must change to achieve the same correction, depending on whether the central limb is short or long.



Figure 40-5. (A) Rotation flap creating trigone deformity of the vermillion border. (B) Trigone deformities and fat lip deformities are evident at suture removal and do not improve with time. (Reproduced with permission from Wentzell JM1, Lund JJ: Z-plasty innovations in vertical lip reconstructions, *Dermatol Surg.* 2011 Nov;37(11):1646–1662).

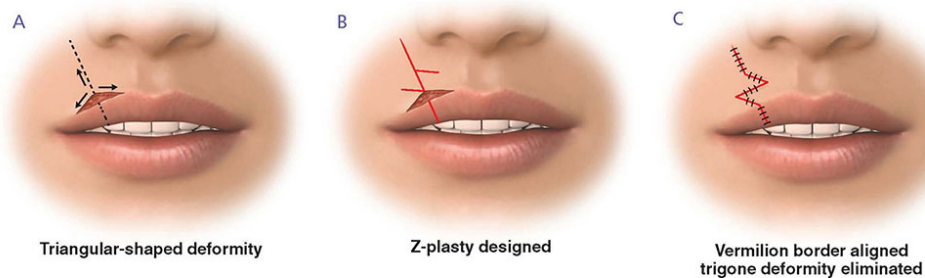


Figure 40-6. (A) When the wound is sutured, tension vectors create forces that pull the vermillion border into a triangular deformity. (B) Z-plasty designed to correct the incipient trigone deformity at the initial closure. (C) With Z-plasty execution, the vermillion border is compelled to follow a smoothly continuous curve.



Figure 40-7. (A) Large upper lip defect. (B) and (C) Vertical revision outlined and initiated. (D) In this case, approximation of wet line does not result in vertical misalignment of vermillion border because the lip's cross-sectional arc of curvature is the same medially and laterally. A sliding Z-plasty is not necessary. However, wound closure completion at this point would result in a “corner” or trigone deformity at the border. (E) and (F) A traditional Z-plasty compels the vermillion border to follow a smoothly continuous line. (G) Long-term result without trigone deformity. (Reproduced with permission from Wentzell JM1, Lund JJ: Z-plasty innovations in vertical lip reconstructions, *Dermatol Surg.* 2011 Nov;37(11):1646–1662).



Figure 40-8. Exaggerated creasing of right upper lip scar due to repeated muscular contraction. (Reproduced with permission from Wentzell JM1, Lund JJ: Z-plasty innovations in vertical lip reconstructions, *Dermatol Surg.* 2011 Nov;37(11):1646–1662).

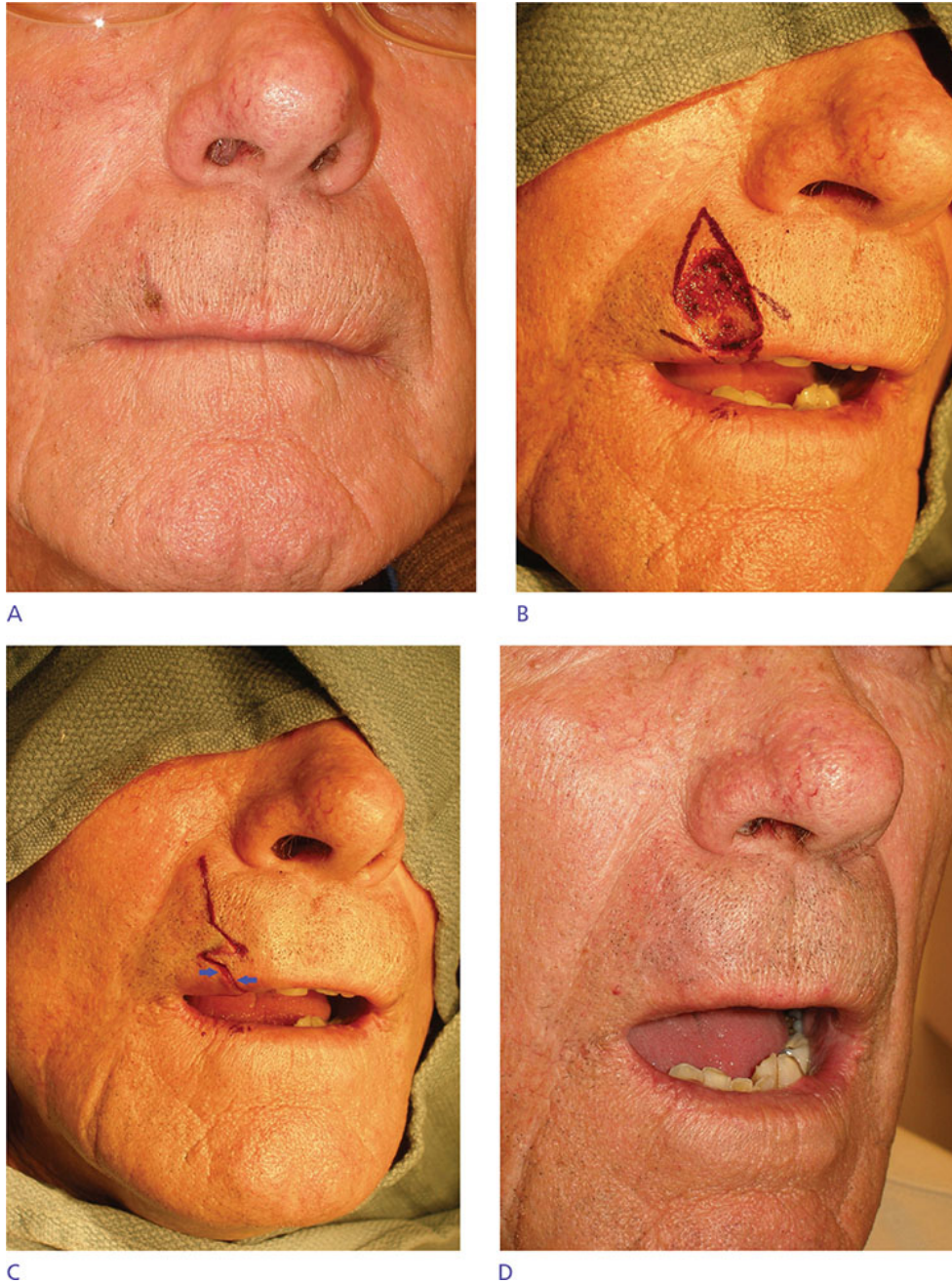


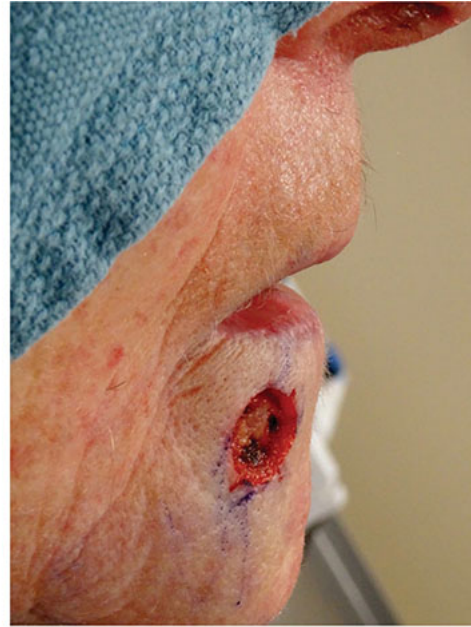
Figure 40-9. (A) Vague vermilion border zone. (B) Defect with Z-plasty outlined. (C) Z-plasty executed. *Arrows* demonstrate misalignment of vermilion border. (D) Final outcome. Misaligned border is imperceptible. Horizontal limb of Z-plasty acts as a reinforcing strut to counter contractile forces that cause exaggerated creasing. (Reproduced with permission from Wentzell JM1, Lund JJ: Z-plasty innovations in vertical lip reconstructions, *Dermatol Surg.* 2011 Nov;37(11):1646–1662).



Figure 40-10. (A) Vermillion border defect. (B) Partial closure just deflecting superior and inferior wound margins to counteract wound contraction forces. (C) Long-term result. (D) Cutaneous lip defect. Complete 3:1 closure would result in inferior dog ear necessitating wound extension through wet line. (E) Wound closed just to the point where superior and inferior wound margin deflection will neutralize opposing contractile forces while the wound heals. (F) Short-term result.



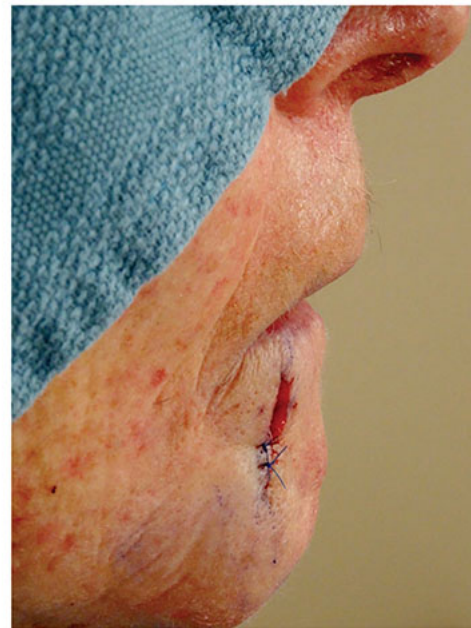
A



B



C



D

Figure 40-11. (A) Typical lower lip defect. (B) Superior aspect of the defect just approaches the apex of convexity. Traditional 3:1 linear closure would create a dog ear deformity at the vermilion or require a vermilion wedge. (C) Closed wound within its own length, compressing the superior aspect side-to-side with deep sutures only. (D) Superior aspect closed just to the point of incipient cone formation; this just counters contractile forces of healing wound to prevent downward contraction of vermilion border.



A



B



C



D





E

Figure 40-12. (A) Moderately sized defect on the upper lip with advancement flap designed along the vermilion border. (B) Standing cone and back cut removed and flap incised. (C) Flap brought into position. Note the residual central defect with Z-plasty marked out. (D) Final closure after central Z-plasty. (E) Long-term follow-up.



A



B

Figure 40-13. (A) Small squamous cell carcinoma of upper lip. (B) Inappropriately large repair with pronounced horizontal limb on V-Y island pedicle advancement flap.

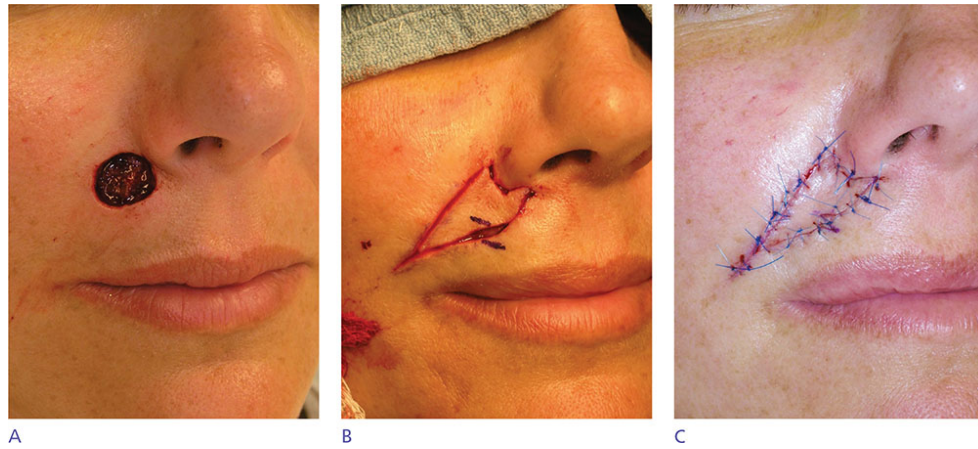


Figure 40-14. (A) Larger cancer excision site compared to Figure 40-13. (B) Appropriately sized V–Y island pedicle marked for Z-plasty. (C) Executed Z-plasty on lower horizontal line will camouflage scar. Two or more Z-plasties can be deployed as necessary.



Figure 40-15. Fish-mouth deformities arise due to the same force vectors as trigone deformities. Scar contracture often contributes.



Figure 40-16. (A) Broad defect into muscularis. (B) Defect appearance after wedge excision. (C) Approximation with incipient fish-mouth deformity. (D) Z-plasty corrects fish-mouth deformity. (E) Final horizontal arm of Z-plasty in labial-mental sulcus.

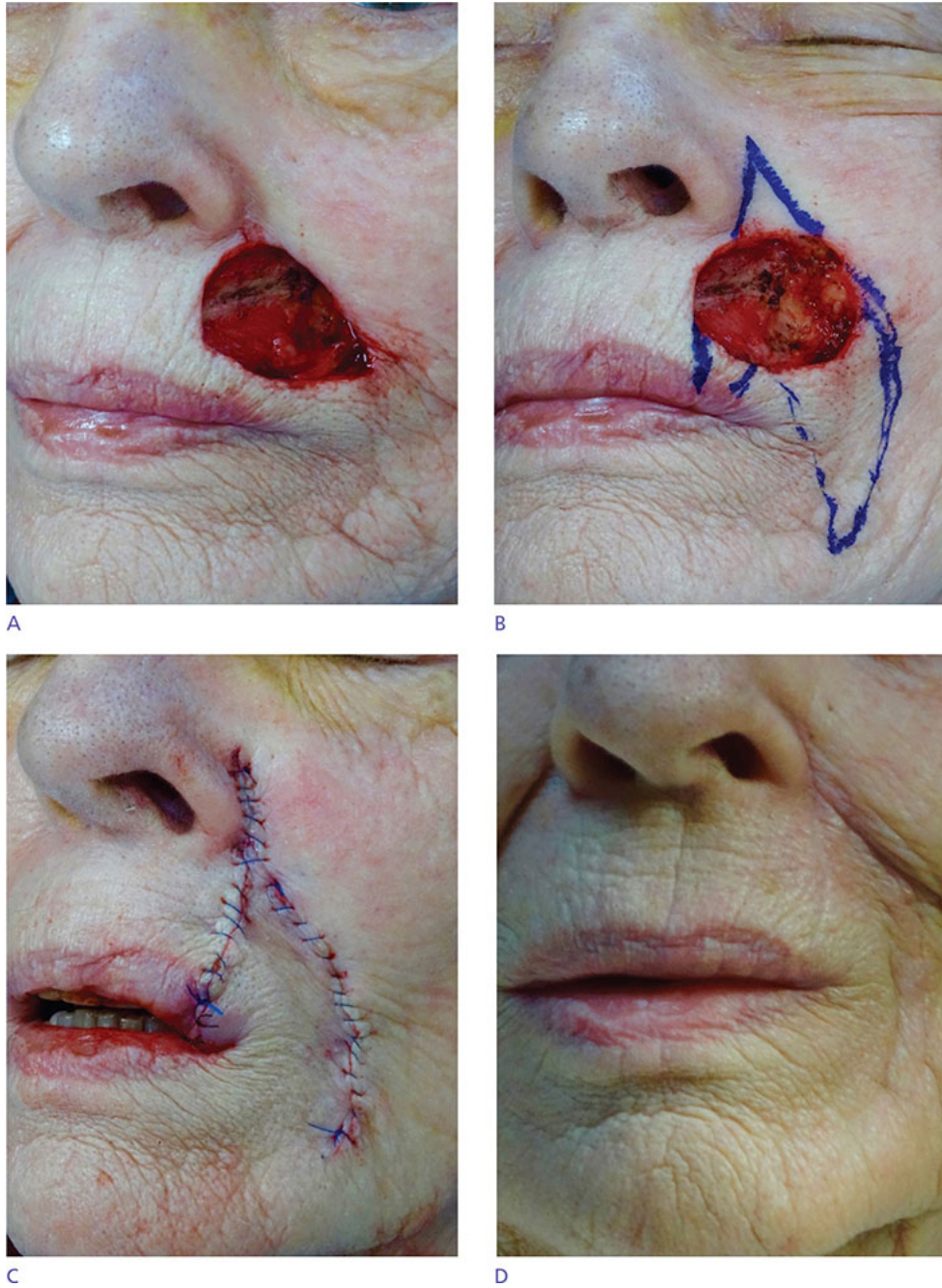


Figure 40-17. (A) Large, deep upper lip defect. (B) Design of combined rotation flap and wedge. Either closure alone would cause significant distortion or possible microstomia. (C) Final closure. (D) Long-term result.

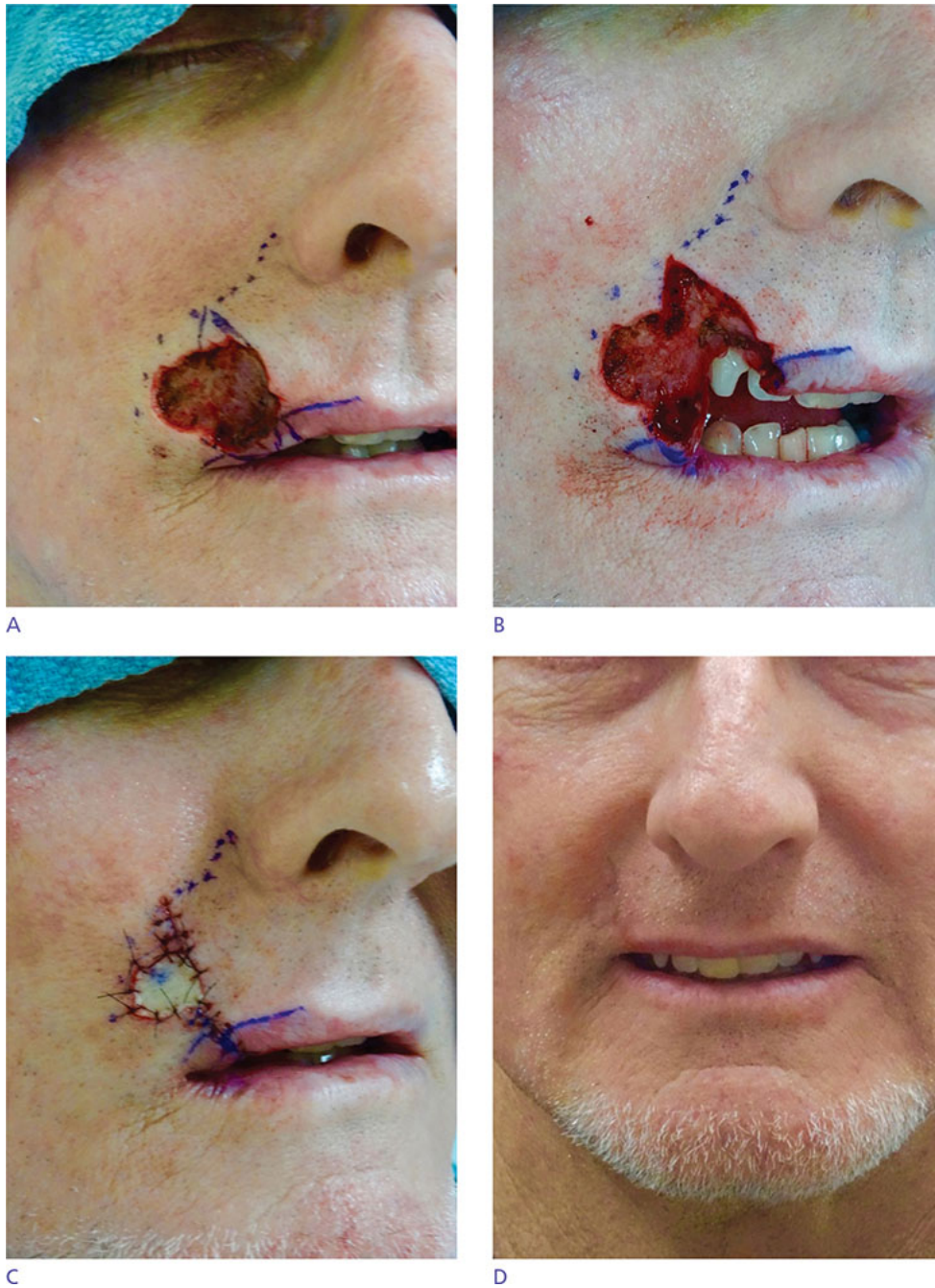


Figure 40-18. (A) Broad defect of lateral lip in youthful face equal to 60% of total width from commissure to mid-upper lip. (B) Medial wedge combined with (C) small lateral graft derived from hair-bearing submental neck crease. (D) Short-term result amenable to dermabrasion. A single flap or graft or wedge would cause much greater distortion and possible microstomia.

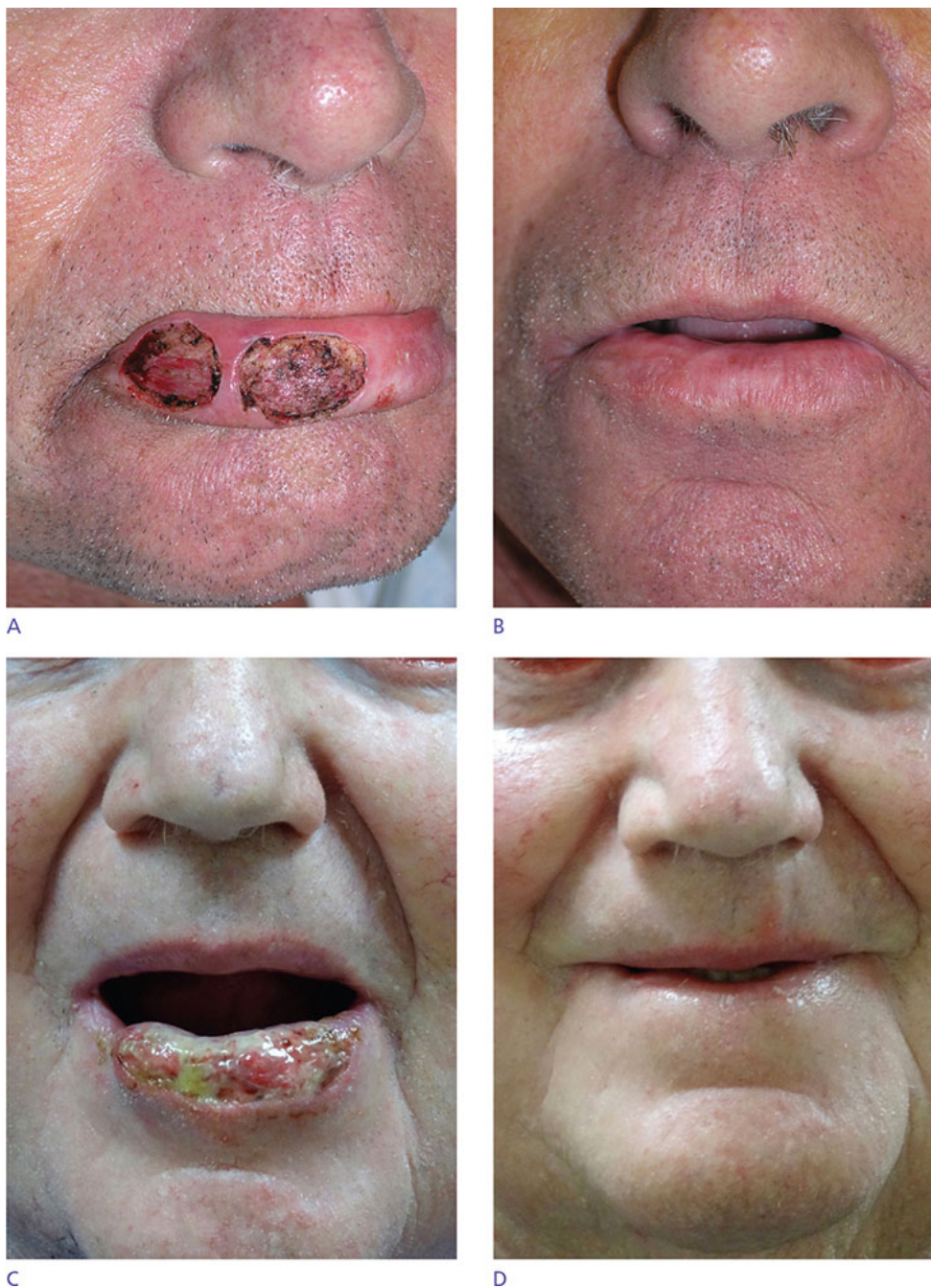


Figure 40-19. (A) Defects extending to muscularis. (B) Final outcome of second intention healing. (C) Two weeks after extensive excision to muscularis. (D) Final outcome with second intention healing. In many cases, second intention healing provides a superior result even for excisions of the entire lower lip, and even those involving muscularis or extending to the cutaneous lip.



Figure 40-20. (A) Rotation flap designed with lateral vermillion wedge to prevent hooding. (B) Flap in position. (C) Z-plasty designed. (D) Flap fully executed. (E) Long-term result. No lateral hooding is seen.

Table 40-1. Common Complications in Lip Reconstruction: Causes and Prevention

Complication	Common Cause	Prevention
Asymmetrical “smile lines”	Narrowing or elimination of the apical triangle during reconstruction.	Maintain the width of the apical triangle by deploying flaps or grafts (Fig. 40-1A–C).
Fat lip deformity (Fig. 40-2)	Aligning vermillion border to close a wound on a lip with broader vermillion medially than laterally (Fig. 40-3A–C).	Align the wet line first and utilize a sliding Z-plasty to align any noticeable vermillion border mismatch (Fig. 40-4A and B).
Trigone deformity (Fig. 40-5A and B)	Arises because of the physics of counterbalancing tension vectors during wound closure (Fig. 40-6A–C).	Utilize Z-plasty to decrease radially directed tension (Fig. 40-7A–G).
Exaggerated deepening of radial scar (Fig. 40-8)	Repeated contraction of orbicularis oris.	Place a small Z-plasty in the vertical (radial) closure line of linear closure or flap (Fig. 40-9A–D).
Persistent “dog ears”	Stopping a vertical (radial) linear closure on a convex surface.	(a) Lengthen wound closure on the cutaneous lip to more than the standard 3:1 ratio. (b) Lengthen the closure of a wound completely through the wet line, creating a mini wedge. (c) Utilize partial closures (Figs. 40-10A–F, 40-11A–D, and 40-12A–E).
Noticeable horizontal scar line on a V–Y island closure (Fig. 40-13A and B)	Horizontal line runs counter to radial expression lines.	Place one or more Z-plasties in lower horizontal line of closure (Fig. 40-14A–C).
Fish-mouth deformity (Fig. 40-15)	This is the midline manifestation of the trigone deformity coupled with scar contracture.	Deploy Z-plasty into vertical repair (Fig. 40-16A–E).
Microstomia	Primary approximation of large lip wounds.	Abbe flaps, transposition flaps, and grafts. Focus on combinations of closures (Figs. 40-17A–D and 40-18A–D).
Foreshortening (narrowing) of lower lip vermillion	Mucosal advancement flaps.	Second intention healing (Fig. 40-19A–D).
Appearance of a cleft lip repair	Loss of philtrum. Linear repairs of philtral defects decrease distance between philtral ridges.	Utilize flaps or grafts that maintain distance between philtral ridges.
Failure of wet line seal	Depression or misalignment of wet line. Often caused by mucosal advancement flaps or retracting trigone forces.	Utilize secondary intention healing. Prioritize wet line reapproximation rather than vermillion reapproximation. Utilize traditional or sliding Z-plasties.
Nonkeratinizing vermillion	Repairs that displace wet mucosa anterior to the wet line.	Where practical, do not displace wet mucosa anterior to wet line. Use second intention and primary closures maintaining dry mucosa on lip.
“Hooding” of the oral commissure	Upper lip rotation or advancement flaps that impinge on commissure.	Trim flap adequately. Where possible, stop the vermillion border incision medial to commissure. Remove wedge from vermillion as necessary (Fig. 40-20A–E).

BIOANATOMY AND BIOMECHANICS

Perceptually, the upper lip is composed of multiple cosmetic subunits (Fig. 40-21).¹ The central philtral subunit is bounded on either side by the philtral ridges, the medial borders of the lateral subunits. The lateral subunits of the upper lip are bounded inferiorly by the vermillion, medially by the philtral ridges, superiorly by the bases of the alae and columella, and laterally by the nasolabial fold. The apical triangle, sometimes called the isthmus, is the small triangular extension of the lip which lies lateral to the ala and medial to the superior most nasolabial fold. While small in size, it provides a

recognizable delineation between the lip, nose, and cheek; it should be maintained as an aesthetic marker whenever feasible.

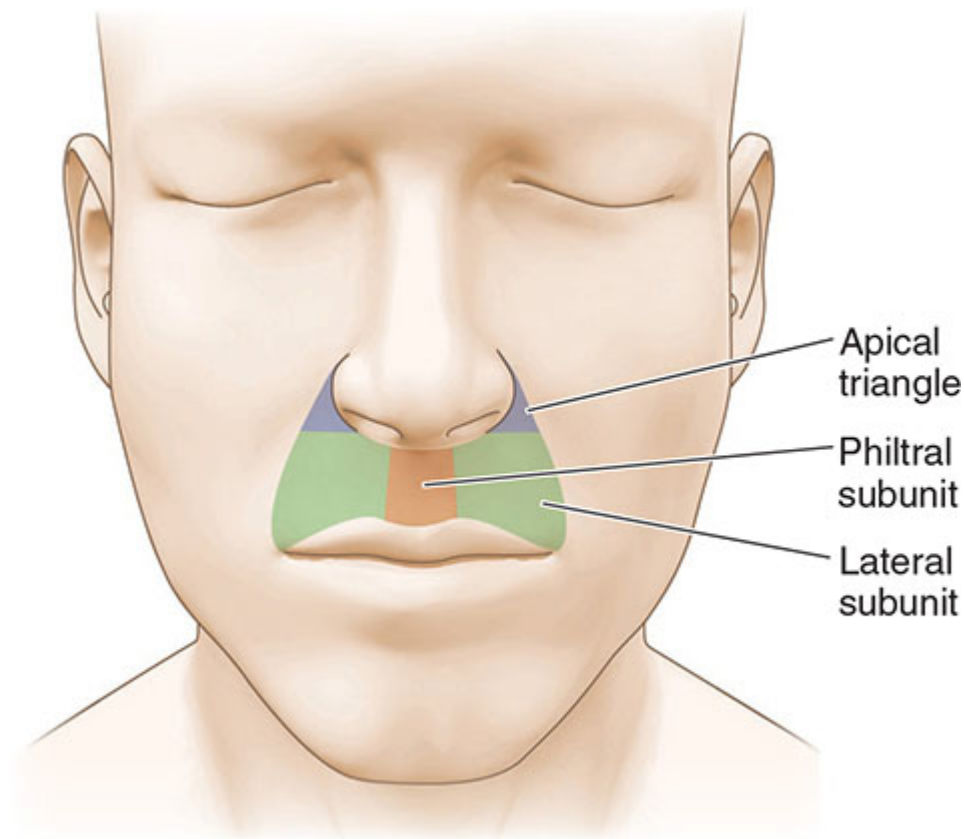


Figure 40-21. Lip subunits: The upper lip is divided into a philtral subunit and two lateral subunits. The lateral subunits each contain an apical or “sacred” triangle lateral to the nasal ala. Maintaining the integrity of the philtrum, apical triangle, and nasolabial folds are goals of upper lip reconstruction.

The inner surface of the lip is the oral mucosa. The wet mucosa becomes vermillion as it exits the oral aperture and forms the red lip. External to the wet line, the vermillion surface represents “dry mucosa.” The keratinizing dry mucosa differs structurally from nonkeratinizing wet mucosa. For this reason, skin grafts of wet mucosa onto the dry mucosa of the vermillion do not mature into dry mucosa. Utilizing wet mucosa to repair the vermillion surface external to the wet line often yields suboptimal results.

Beneath the mucosa is a submucosal layer rich in minor salivary glands. The vermillion itself lies directly on a circumoral band of orbicularis oris and the underlying musculature has rich vascular supply. This leads to the red color of the lips. The structural bulk of the lip is composed of the orbicularis

oris, which forms circumferential rings and gives the lips their shape, definition, and function.

The facial nerve provides motor innervation for the perioral musculature via its zygomatic, buccal, marginal mandibular, and cervical branches. These nerves are highly anastomosed and deeply seated. Therefore, neural injury leading to a functional impairment of perioral function is rare, with the one exception being damage to the marginal mandibular nerve as it passes along the mandible. The infraorbital nerve provides sensory function to the upper lip, and the mental nerve innervates the lower lip (Fig. 40-22).

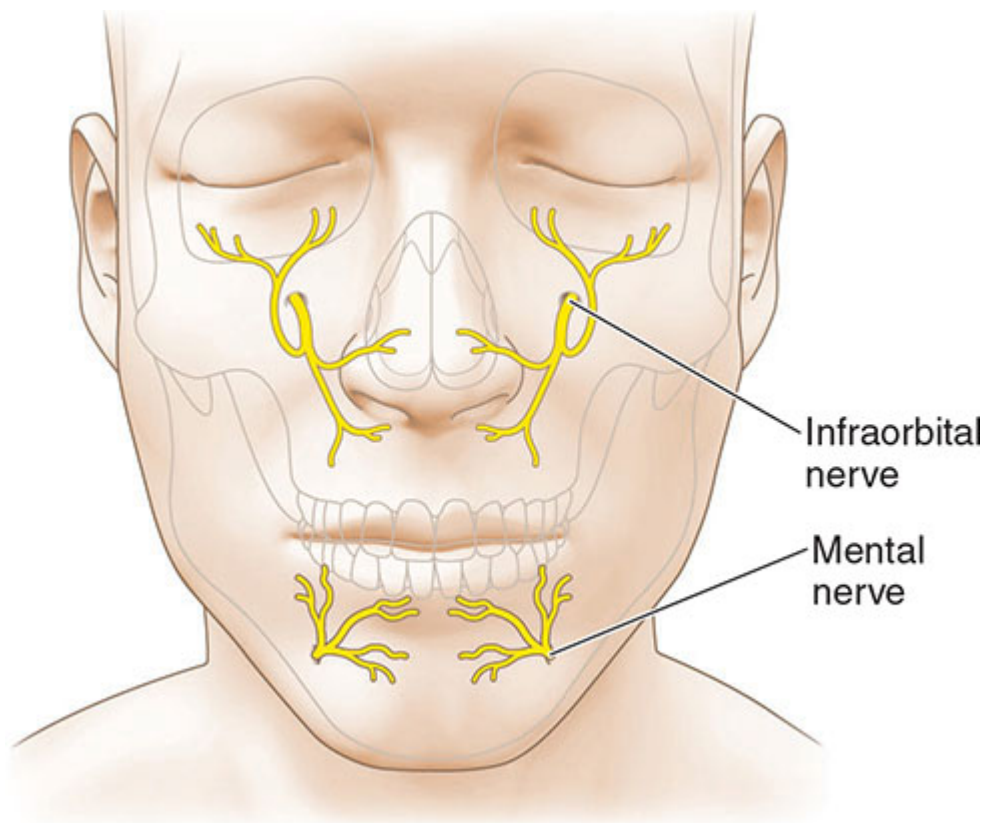


Figure 40-22. Sensory innervation of the perioral region. The upper lip is innervated by the infraorbital nerve and the lower lip is innervated by the mental nerve. The lateral commissures receive sensory input from the cervical nerves and require separate local anesthetic.

Anesthesia of the lip is readily achieved by nerve block (see [Chapter 12](#)). The upper and lower lip each receive a large branch from the facial artery as it ascends toward the alar crease (Fig. 40-23). The arteries run in the submucosa and become tortuous with age. They give off many perforators and branches, anastomosing at the midline.

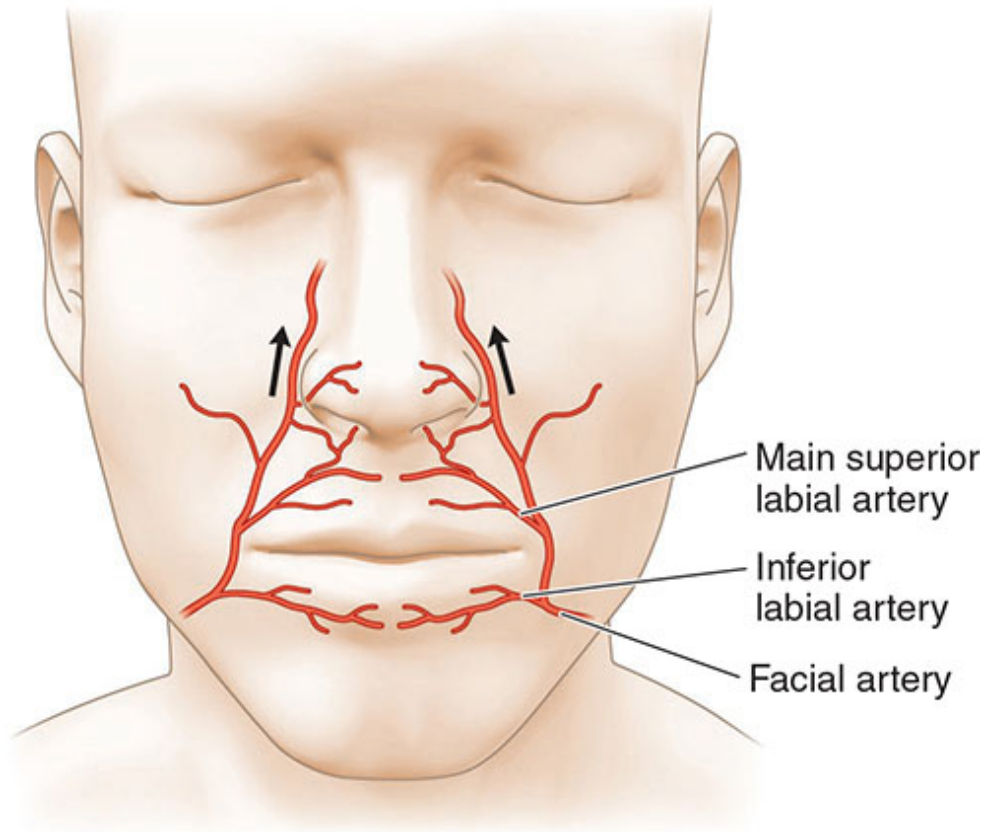


Figure 40-23. Vasculature of the perioral region. The upper and lower lips are richly supplied by large labial branches of the facial artery. The labial branches are tortuous with age and run on the submucosal side of the orbicularis oris.

The junction of the vermillion and the cutaneous lip is a bright, clear line in younger adults. A thin, elevated, well-defined band of pale glabrous skin (the white line) marks the border with the cutaneous lip. With age, this definition fades progressively until the vermillion border is no longer a line but a vaguely defined zone up to 4 mm wide where vermillion blends in a continuum with the cutaneous lip. The reconstructive surgeon must remain keenly aware of the width of this vermillion/cutaneous transition. If the patient has a white line, the repair must be meticulous, reapproximating the white line on apposing wound margins. If the vermillion/cutaneous transition is a wider “zone” of transition, the vermillion alignment is less critical. The observing eye will not notice the repair scar as long as the vermillion “border” on either side of the repair falls within the vaguely defined “zone.”

The youthful lip often has a prominent philtrum, and the vermillion border of the upper lip is crisp and voluminous. The nasolabial folds are not well

developed in youth. Instead they are soft, minimally depressed inclinations. With age, the upper lip flattens, the philtrum is less prominent, and the vermillion border is less defined. The nasolabial folds become fixed and sharply recessed, clearly defining the lateral margin of the upper lip (Fig. 40-24).



Figure 40-24. Variation in the lip with age. (A) Lips of a 25-year-old woman. The vermillion is full and sharply defined. The philtrum is elevated and distinct. Repairs may be noticeable, even if the scar line is fine and sharp. (B) Lips of a 45-year-old woman. The vermillion has lost some volume. The philtrum has lost some elevation and is less distinct. A few vertical lines have formed. (C) Lips of a 65-year-old woman. Volume loss and loss of the philtrum are more advanced and vertical rhytides are more pronounced. Repairs are often less visible.

There is tremendous variation in the shape of the perioral region, and this has an impact on reconstruction (Fig. 40-25). Some individuals have a small oral opening, while others have a broad, wide mouth. The upper lip may be high and arched, or low and flat. The distance from the columella to the vermillion varies dramatically from person to person, as does the span from commissure to commissure. While most younger individuals have a prominent philtrum, in some it is minimal even in youth. In some older

individuals there is no residual philtrum at all. Such variation impacts operative reconstruction, as what may be a simple repair in some individuals can be a challenge in others.



Figure 40-25. Variations in size and configuration of the mouth/lips. (A) Small oral aperture. Loss of any substantial component of the oral diameter may lead to relative microstomia. (B) A broad upper and lower lip make reconstruction easier in the event of a sizeable defect.

This chapter focuses on the aesthetic and functional repair of modest wounds of the upper and lower lip. A storied history of reconstruction of the lip for large wounds dates to the late 1500s and involves some of the historically great reconstructive surgeons. In recent decades, dermatologic surgeons have greatly expanded the available repertoire of sophisticated reconstructions. While generally beyond the scope of this text, the artistry and geometry involved in the history of extensive wound lip reconstruction are well worth examining.²

REPAIR-RELATED DEFORMITIES

Any surgical wound of the lip can be repaired successfully in a variety of ways. By and large, the art of reconstructive surgery is the art of minimizing deformities. During reconstructive planning and execution, the foremost question in the surgeon's mind must be, "How do I best serve this patient's goals?" If those goals are best served by a reconstructive effort, the next most important question to ask oneself is, "How do I minimize noticeable deformity?" and not "How do I close this wound with XYZ closure?"

To develop the "deformity avoidance" mindset, the reconstructive surgeon must have a thorough understanding of how deformities arise during and after

reconstruction. A mental catalog of possible deformities and their causes is more important to the reconstructive surgeon than the mental catalog of the repairs in the surgeon's toolbox. [Table 40-1](#) reviews some of the more salient deformities that the reconstructive surgeon should minimize or avoid altogether.

[Figure 40-6](#) demonstrates why a trigone deformity develops. In an upper lip wound, for example, if the medial vermillion border is oriented horizontally, but the slope of the lateral border is oblique, the original forces on the lip change when the surgeon approximates wound margins. A new upward force and a new medial force (defined by a single composite tension vector) now act on the wound's lateral vermillion border. There is a concomitant two-component (lateral/downward) composite force now applied to the medial vermillion border.

When two forces act on a single point, that point will move along the net vector. Physics dictates that the movement continues until either (a) the original tension vectors are aligned at 180 degrees (i.e., the slope of the vermillion border is perfectly flat) or (b) the net tension vector along which the point moves is ultimately opposed by an equal and opposite tension vector.

In practice, "b" is the only scenario that happens if one sutures two sides of a wound whose opposing medial and lateral vermillion borders are not horizontally co-linear. In this case, a "corner" will form along the vermillion border at the physical point where there is an equalization of the three tension vectors. If the angle of that "corner" is broad, the effect is minimally noticeable. As forces increase, however, the angle becomes more acute; there will be a progressively more noticeable "corner" at the vermillion border.

This is termed a "trigone deformity." It does not occur in suturing the wound in a thin, flat lip, as there is no upward or downward force on the rejoiner vermillion border.

A trigone deformity is an inevitable outcome of the physics of tissue movement in a lip with vermillion border of changing slope. It can accompany a fat lip deformity, though this does not occur consistently. While the trigone deformity relates to the changing slope of the vermillion border, the fat lip deformity relates to the changing cross-sectional arc of curvature.

UPPER LIP

Lateral subunits

The lateral subunit of the upper lip is bounded by the nasolabial fold, the alar crease, the philtrum, and the vermillion border. Nonmelanoma skin cancer of the upper lip is very common. Hence, repair of the upper lip lateral subunit is a frequently required reconstruction.

Partial repairs

The figures and discussions included in [Table 40-1](#) demonstrate that partial repairs of the lip can offer acceptable results with minimum morbidity and reduced cost ([Fig. 40-10](#)). This is true even when the defect straddles the vermillion border. Patient selection, of course, is of critical importance. Repairs can often be executed without significant extension or conversion to a fusiform shape, and no attempt to excise incipient standing cutaneous cones. Partial repairs can dramatically foreshorten the length of the repair, averting standing cutaneous cone formation over the perioral convexities.

The key to partial repairs is to tighten the sutures (buried and/or surface, at the surgeon's discretion) just to the point where incipient standing cutaneous cone formation begins. With experience, the surgeon can know exactly how much cone formation will be exactly countered by the healing-process wound contraction. A flat scar of absolutely minimum length will result. In most cases, the surgeon should move up one suture diameter and leave sutures in place for roughly an extra week to prevent respreading of the wound with suture removal. In other words, as a rough approximation, if a linear closure at the site typically requires 6-0 suture removed at 10 days, the partial repair utilizes 5-0 suture for 2½ weeks. As the wound contracts, the suture typically becomes lax and irrelevant. Of course, one may elect no surface suture at all, tensioning the wound with only deep sutures.

Linear repairs

Small and modest wounds of the mid-upper lateral subunit may be repaired linearly ([Fig. 40-26](#)). Vertical lines on the lip are common with age. With

proper execution, such repairs can be highly aesthetic and lead to minimal or no functional impairment. The most appropriate wounds for a linear repair are those which lie above the vermillion border and whose vertical axis is longer than the horizontal axis. Linear repairs on the lip do not need to be exactly vertical. They generally should parallel the philtral columns medially but remain perpendicular to the vermillion border as it arcs slightly with its lateral procession. Linear repairs on the lip must be long and should be carried right through the vermillion border.³ In most cases, the outermost orbicularis band should be transected and excised as a “mini wedge,” without which a standing pucker of lip will often exist (Figs. 40-27 and 40-28). Dog ears on the lip do not recede, and therefore the repair must be long enough and deep enough (just above orbicularis) to ensure that it lies flat at the moment of closure. In addition, the sharper the defining line between the vermillion and cutaneous lip, the more meticulous must be the alignment of apposing wound margins. In patients with a well-defined white line, even mismatch of a millimeter or less of vertical height will create a visible deformity and ruin what may otherwise be a nearly invisible repair. Patients with a vaguely demarcated vermillion border “zone” require less meticulous vermillion border alignment.



Figure 40-26. For modest wounds of the lip a vertical linear closure is an excellent repair. (A) A vertically oriented wound on the lip and a linear repair design for closure. (B) The closure is long and passes right through the vermilion border in order to avoid a pucker at the inferior margin. (C) Final result at 1 year with aesthetic repair.



Figure 40-27. Fullness and puckering of the vermilion following a vertical linear repair. This is particularly problematic when smiling as it shows against the teeth. This can be avoided in most cases with proper planning and technique. (A) Immediate linear repair on the lip showing fullness and “bulldozing” of the upper lip vermilion. This can be avoided by removing the distal orbicularis oris band. (B) Photo at 6 months demonstrating resolution of most puckering, but still some fullness of the lip.



Figure 40-28. A slightly larger wound on the upper lip is repaired with a linear closure in which the distal/surface band of orbicularis oris is removed. (A) Operative wound. (B) The repair is performed in the potential space above the orbicularis musculature and is extended right through the vermillion border. The distal/surface band of orbicularis is excised and repaired as a “mini wedge.” (C) Immediate closure without pucker formation. (D) Aesthetic closure healing at 3 months.

Lip wedge

Wounds involving the vermillion border of the lateral upper lip are common. Many such defects can be repaired with a full-thickness or modified full-thickness wedge reconstruction (Fig. 40-29).⁴ As originally defined, the wedge is a full-thickness V-shaped transmural repair. The operative wound edges are squared off and a full-thickness V-shaped “pie” of tissue is excised up to the gingival sulcus. The labial artery is either ligated or electrocoagulated, and the repair is then closed in a multilayer fashion. The mucosa is first closed with an absorbable suture such as plain gut. The muscle is then reapproximated with an absorbable buried suture, the dermis is separately repaired and then the epidermis and vermillion mucosa are reapproximated.

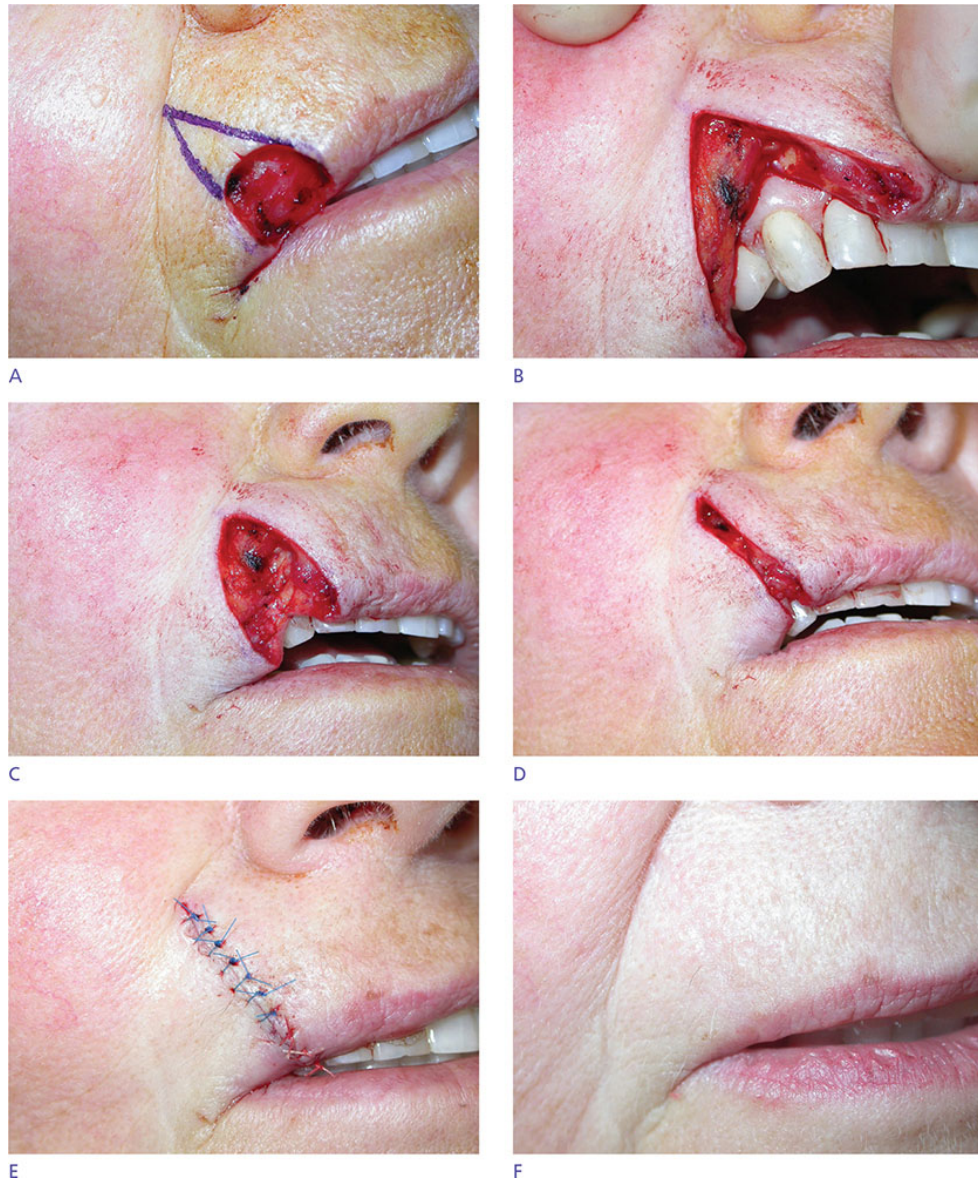


Figure 40-29. A modest wound of the lateral upper lip and vermilion is repaired with a wedge. (A) Operative wound and planned wedge. (B) A full-thickness excision has been accomplished. (C) The mucosa has been repaired. (D) The orbicularis oris has been reapproximated. (E) Repair at completion with careful matching of the vermilion border. (F) Repair at 6 months.

As with the simple partial-thickness closures, in patients with a sharply defined white line it is imperative to carefully match the vermilion borders. If the defect is broad and the lip narrow, a wedge will lead to a mismatch between the smaller lateral cutaneous lip and vermilion and the taller more substantive medial remnant. The result will be a functional lip but a visible mismatch. This may be a tolerable deformity but should be considered if the

patient has high cosmetic expectations. A sliding Z-plasty technique can effectively overcome this mismatch.⁵

A wedge reconstruction of any defect that encompasses more than one-quarter of the upper lip has the potential to cause microstomia; for larger wounds, combination repairs, rotational flaps, and lip-sharing procedures may be preferred. The advantage of a lip wedge is that it is a relatively nonmorbidity repair with a low risk of complications. As with partial-thickness repairs, wedges need not be entirely vertical but should align with radial relaxed skin tension lines (RSTLs) that are typically perpendicular to the vermillion border.

Any vertical line scar on the upper or lower lip can demonstrate exaggerated creasing with time, due to repeated contraction of the orbicularis oris muscle. A Z-plasty (traditional or sliding) incorporated into the vertical incision line of a linear repair, wedge, or flap acts as a strut that resists this creasing. When the Z-plasty is executed, the depth of incision for the arms of the Z-plasty is typically down to muscularis. In practice, the final horizontal central limb of the Z-plasty is not noticeable.⁵

A modification of the lip wedge avoids extending the repair all the way to the gingival sulcus and preserves some muscle (Fig. 40-30).⁶ In the modified technique, the external repair is extended the full vertical height of the lip, but the internal extent is only about 50% of the height of the lip. The distal band of orbicularis is completely severed, as is the labial artery, but the larger, deeper major circumoral band of orbicularis is preserved. This repair is less extensive than the full-thickness wedge and may preserve a more normal circumoral muscle tone in the postoperative period. From an aesthetic standpoint there seems to be little difference from the standard lip wedge.



Figure 40-30. A modified wedge repair is performed as a partial-thickness closure without extension all the way to the gingival sulcus. (A) Operative wound and planned repair. (B) The wedge has been accomplished by excising the entire vermilion and all of the distal bands of the orbicularis oris. The labial artery has been ligated and transected. The upper bands of the orbicularis are preserved, and the wound edges are undermined free of the muscle. (C) The repair is closed by repairing the mucosa and the distal orbicularis band. (D) Immediate result without lip distortion. (E) Aesthetic repair at 6 months.

Advancement

Many moderate to large cutaneous wounds of the upper lip lateral subunit can be suitably repaired with unilateral advancement flaps (Figs. 40-31 to 40-

33).^{3,7-9} These large repairs use laxity from the medial cheek to allow for a nearly tension-free closure, thus avoiding philtral and vermillion distortion.



Figure 40-31. Figure and photos demonstrating a cheek advancement for a sizeable operative wound on the medial aspect of the lateral subunit. (A) Operative wound. A linear repair or wedge would distort the lip and displace the philtrum. A graft would be highly unaesthetic. (B) A large advancement flap is designed with crescentic standing tissue cones to be removed around the ala and lateral to the oral commissure. (C) The flap is elevated above orbicularis. This is an area with rich vasculature, and precise hemostasis is essential. (D) Immediate closure. The most challenging aspect of this repair is judging the effect of the advancement on the position of the lateral upper lip/vermillion. (E) Repair at 6

months demonstrating normal form and function and excellent cosmesis. (Used with permission from Dr. Todd Holmes).



Figure 40-32. In a modification of the prior repair, a large upper lip wound is repaired with a cheek advancement and a separate vermilion advancement (A) A large operative wound might be repaired with a lip wedge, but the patient is a tuba player and wishes to maintain his embouchure. (B) Advancement is designed to tap into laxity of the medial cheek. A crescentic standing tissue cone is delineated around the alar margin. (C) The flap is elevated out to and beneath the nasolabial fold. (D) The repair at completion. The vermilion has been undermined and advanced/rotated separately. (E) Repair at 9 months demonstrating mild asymmetry.



Figure 40-33. A large defect of the left upper lip is repaired with a cheek advancement and a mucosal island pedicle flap. (A) Operative wound encompasses much of the lateral subunit and includes a mucosal defect. (B) The mucosal wound has been repaired with a mucosal island flap. (C) Advancement planned. (D) The flap has been advanced into place. (E) Final result at 1 year demonstrates normal lip contour. There was some tension on this repair, and the scars are visible and hypopigmented.

For defects near the vermillion, a standing tissue cone is removed superiorly and a broad flap is advanced from the lateral lip and medial most cheek. The design includes an inferior base which parallels the vermillion

border just a millimeter above it and extends lateral to the oral commissure, where a standing tissue cone is removed as the flap advances. The flap is elevated in the plane just above the orbicularis oris. When the nasofacial sulcus is reached, a reservoir of freely mobile tissue is tapped. The flap is thus freed of essentially all pivotal restraint. The flap should not be bulky and, in general, does not include any muscle fibers. The pedicle is from the superolateral aspect of the flap. Freed from all lip restraints, the flap may be advanced without distortion of the lateral vermillion. It is essential that all tension be directed in a horizontal plane. Substantial attention to detail is required to ensure appropriate positioning of the lateral lip to avoid any tension on or depression of the ipsilateral vermillion. If in doubt, it is better to slightly depress the oral commissure rather than elevate it, as slight depression is easier to correct in follow-up. In most cases, the strong musculature of the perioral region will reestablish the position of the mouth within several months such that prolonged positional distortion is rare, though every effort should be made to have a tension-free closure.

For defects closer to the nose, or for very large defects of the upper lip, a modified advancement flap includes an arciform standing tissue cone that extends up and around the nasal ala and alar crease. By extending the repair superiorly and around the ala, the entire medial cheek can be mobilized. Even extensive lip wounds can be suitably repaired in this manner. When the surgeon elevates such flaps, it is important to avoid transferring a deep, bulky flap onto the upper lip. The base of the flap is broad, and the blood supply is reliable. As such, a relatively thin flap may be advanced with confidence. Even appropriately thin upper lip advancements may pincushion for a period of several months, though as a rule they will eventuate in an aesthetic repair. Thicker flaps without adequate undermining, and those with improper sizing, will remain bulky and unsightly appearing as a finger of tissue seemingly placed onto the lip, and in these cases revision is needed.

All upper lip advancements have an impact on the nasolabial fold, and asymmetry is a consequence. The aesthetic compromise of an absent nasolabial fold is usually offset by repair of a more important location, namely the upper lip, but this expectation should be discussed with the patient prior to repair. If needed, the nasolabial fold may be recreated at a later date.

Rotation

Rotation flaps are niche repairs on the upper lip, but can prove exceptionally valuable in the appropriate situation (Fig. 40-34).¹⁰ Defects amenable to rotation are small to moderate wounds of the lateral subunit in the perialar region. Such wounds are often repaired with island pedicle flaps (see below). If the wound is repaired linearly, the superior standing tissue cone removal compromises the apical triangle of the lip. The ideal candidate is a patient with a relatively high and broad upper lip and a prominent arciform nasolabial fold. The repair is designed by dropping a standing tissue cone from the wound to the vermillion border. The arc of rotation extends along the nasolabial fold. The flap is elevated above muscle and all the way to the vermillion border. In this rotation, tension is directed in large part along the primary tension vector, and the rotation is used to eliminate tissue redundancy. The rotated arc can generally be sewn out along the nasolabial fold without removal of a dog ear. It is important only to utilize this repair when the wound is relatively small in relation to the size of the lateral subunit. If there is too much rotational torque on the flap, the lateral vermillion can be elevated, thus resulting in a sneer appearance.



Figure 40-34. Rotation flap for a wound of the apical triangle region. (A) Operative wound and planned repair. The crescent of the repair extends down the nasolabial fold. (B) The flap is incised. (C) The flap is elevated above orbicularis. (D) Flap at suturing preserves the apical triangle and minimally resets the nasolabial fold. (Used with permission from Dr. Todd Holmes).

Island pedicle flaps

Island pedicle flaps are excellent repairs for defects of the lateral upper lip and apical triangle (Fig. 40-35).^{11–13} Even substantial operative wounds can be reliably closed with an island flap based on the perforators of the orbicularis oris and surrounding perioral vascular plexus. Island pedicle flaps are most valuable when one or more limbs of the flap can be hidden along a pre-existing line. If all three lines of the flap are visible “floating” on the lateral upper lip, the result is not aesthetic. Modest wounds of the apical triangle are particularly well suited to the island pedicle flap, as the outer limb of the flap is hidden within the nasolabial fold. In some cases it is useful to enlarge the operative wound to encompass the entire apical triangle region. Such repairs should be designed with adequate width to allow for

closure of the operative wound without tension along a secondary vector. The length of the flap is tailored to allow for the advancement needed for the primary motion to close the operative wound. In general a longer flap is easier to elevate, advance, and suture. A Z-plasty modification of the lower horizontal line can enhance results (Fig. 40-14A–C).¹⁴

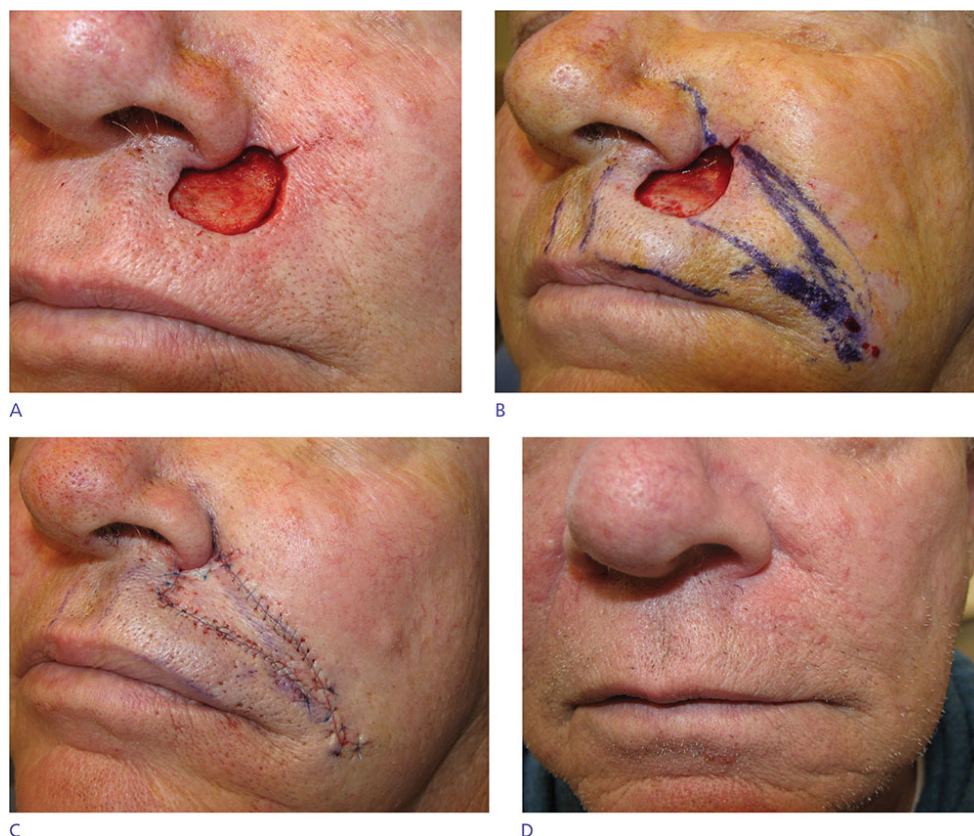


Figure 40-35. Classical repair of an upper lip wound with an island pedicle flap. (A) Wound of the left upper lip near the apical triangle. (B) Island flap design. The upper outer limb of the flap approximates the nasolabial fold. (C). The repair is advanced into place. The pedicle for this flap may be a deep muscular pedicle or a superolateral fatty pedicle. (D) Final result at 6 months.

Labial island pedicle flaps are incised just to the underlying orbicularis oris. The surrounding tissues should be undermined just above muscle. The advancing margin of the flap must be undermined to avoid a “bulldozing” phenomenon and the posterior, lateral, and inferior restraints must be meticulously freed. In order to achieve an aesthetic repair the flap should advance under little tension. A small but well-mobilized pedicle is favored over a bulky, adherent one. Slightly inseting the island and undermining the remaining lip widely can minimize pincushioning. Even when performed

elegantly, some trap-door effect is common for these repairs, though this will reproducibly diminish with time. When the operative wound includes an undermined region of the nose, the advancing margin of the pedicle may be de-epithelialized and advanced under the remnant ala (Fig. 40-36).



Figure 40-36. An island flap may be used to recreate a base for an undermined alar defect. (A) A large defect involves the apical triangle, much of the upper lip lateral subunit, and a small portion of cheek. A cheek advancement will close the defect of the nasofacial sulcus and an island flap is designed to repair the lip wound and stabilize the ala. (B) The cheek has been advanced medially and the island has been advanced underneath the ala to support it. The leading edge of the island has been de-epithelialized. (C) Repair at 1 year. (D) There is some asymmetry, as the apical triangle has been ablated and the nasolabial fold has been moved medially. This could be repaired with a Z-plasty if the patient so desired.

Large, even extensive operative wounds of the upper lip can be repaired with an island pedicle flap that straddles the nasolabial fold and extends out onto the cheek, lateral and inferior to the oral commissure (Fig. 40-37). This type of island flap is based not on the orbicularis oris, but on the richly vascularized adipose tissue of the medial cheek. Wounds of up to 3 cm can be closed readily with broad, large island flaps. In such cases, the flap is

undermined entirely off the orbicularis oris. The lateral pedicle is preserved, and the trailing tension vector is completely severed. The skin of the cheek is dissected free of the pedicle at a shallower plane. This is a robust flap, as it pulls the facial artery medially with it as the wound is repaired. As noted above, peripheral undermining and a slight inset of the flap at suturing can diminish pincushioning in the postoperative period.

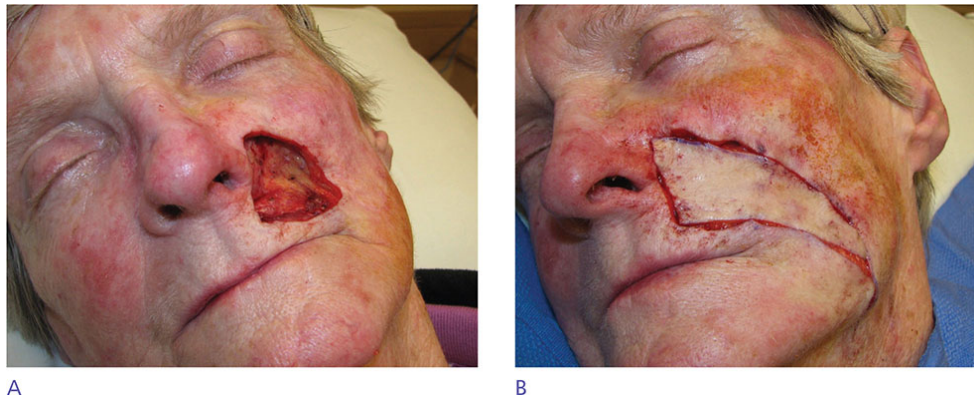


Figure 40-37. Very large wounds of the upper lip may be repaired with island flaps. (A) Large wound of the lateral upper lip. (B) Repair with a large cheek island flap based on a fatty pedicle.

Nasolabial flaps

Inferiorly based nasolabial flaps can be used to resurface very large operative wounds of the lateral upper lip subunit.^{9,15} Appropriate defects are those that are very long in a horizontal plane and which do not involve the lip margin. The flap is designed along the nasofacial sulcus superiorly toward the medial canthus. As the cheek is closed, the flap transposes into place to repair the lip wound (Fig. 40-38). The reliable vasculature and easy mobility of this repair allow for predictable flap survival. This repair has the potential for two problems. It ablates the nasolabial fold, and the flap tends to be bulky and prone to pincushion. The bulkiness and pincushioning can be minimized by appropriate undermining of the recipient lip and by dramatic thinning of the flap prior to inset. The pedicle for a nasolabial flap is richly vascular; it can be reliably thinned to very superficial adipose. The nasolabial fold can be recreated at 6 months with a standard Z-plasty (Fig. 40-39).



Figure 40-38. Nasolabial transposition flap to repair an upper lip wound. (A) An oval horizontal wound presents a reconstructive challenge. (B) An inferiorly based nasolabial flap is designed. (C) The flap has been elevated and sutured into place. This will ablate the nasolabial fold upon healing.

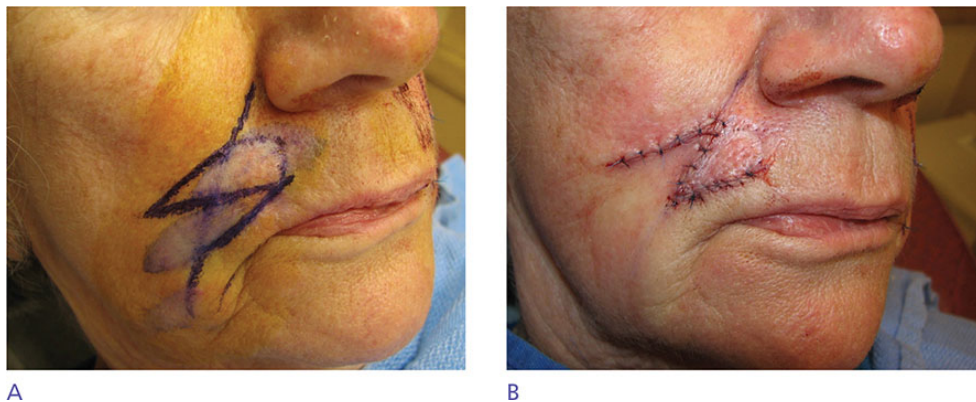


Figure 40-39. Revision to recreate a nasolabial fold. (A) A flap has ablated the nasolabial fold. A Z-plasty is designed to recreate the fold. (B) The Z-plasty is transposed and sutured into place.

Occasionally, a nasolabial interpolated pedicle flap can be utilized for large wounds of the upper lip without involvement of the nasolabial fold (Fig. 40-40). The flap is elevated, much as in the single-staged procedure,

but then bridged over the recreated nasolabial crease. A thin and mobile pedicle is usually well vascularized. The flap can then be thinned dramatically at the time of take down in 2 to 3 weeks. A period of pincushioning is to be expected, and revision may be needed.

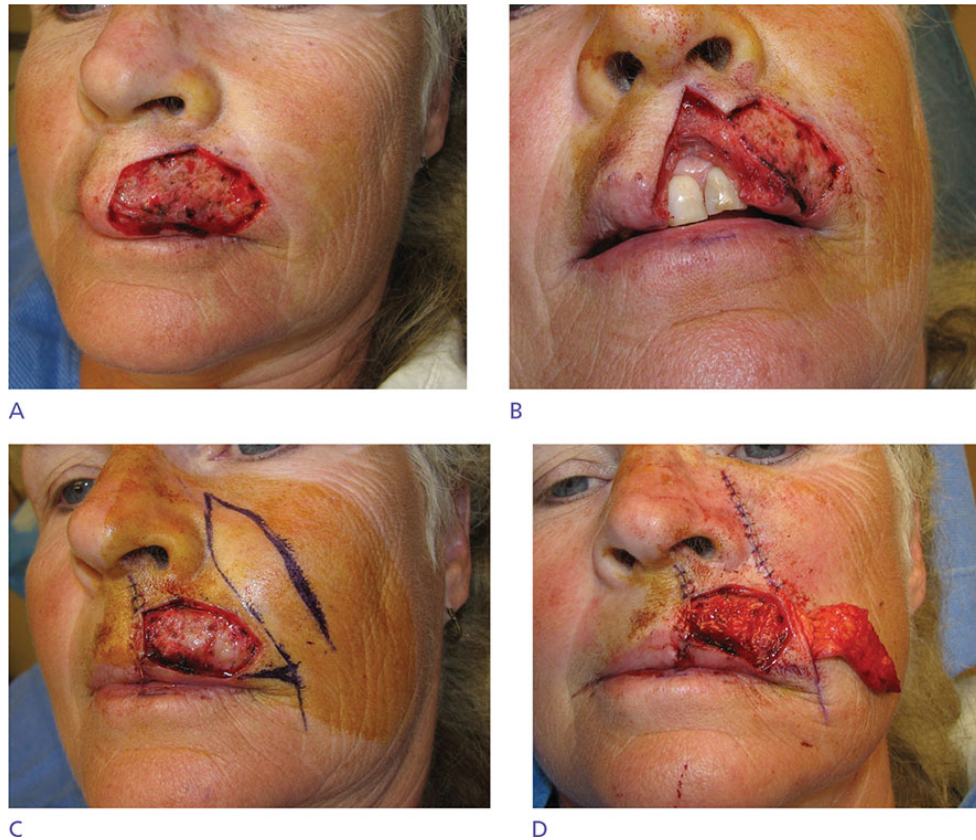


Figure 40-40. Extensive upper lip wound repaired with a partial lip wedge, a mucosal island flap, and a cheek to lip interpolated pedicle flap. (A) Very large upper lip wound demands a creative approach. (B) About one-third of the repair is designed and implemented as a full-thickness lip wedge. (C) The wedge is closed, making the wound manageable, and an inferiorly based nasolabial interpolation flap is designed. The mucosal lip has been advanced. (D) The nasolabial flap has been elevated, and the cheek wound repaired.



Figure 40-40. (E) The nasolabial flap has been extensively thinned and sutured into place as an interpolated flap. (F) Mature flap prior to division. (G) Slightly bulky flap at 9 months. (H) Flap is elevated for debulking. (I) Material excised from undersurface of flap for thinning. (J) Immediate revision.

Full-thickness skin grafts

A commonly heard but ill-founded mantra is, “Do not use skin grafts on upper lips.” Yet skin grafts can be exceedingly useful and aesthetically acceptable, especially for large partial-thickness upper lip repairs. They are

very reliable and maintain function without the risk of bulky thickening. Flexibility and dynamism of the repair is excellent. Skin grafts can be executed with minimum morbidity, a significant advantage for elderly patients. Cosmesis can be very good to excellent, provided the surgeon takes care in execution. Upper lip skin grafts may increase in laxity over time, though this may be advantageous. The laxity provides an excellent opportunity to perform easily tolerated serial excisions, converting large grafts to small unobtrusive grafts. This serial excision technique for upper lip grafts can also permit reconstitution of a previously compromised vermillion border. The surgeon should not dismiss out of hand the utility of a full-thickness skin graft, especially for larger partial-thickness upper lip repairs.

HORIZONTALLY ORIENTED DEFECTS NEAR THE VERMILLION

Gull-wing flap

Oblong defects with a long horizontal dimension and short vertical component present a special challenge. Often they can be repaired with a niche reconstruction known as a gull-wing flap (Fig. 40-41).¹⁶ In patients with a suitable lip height, the defect may be incorporated into the arc of a seagull's wing, with the center of the gull based at the vermillion border of the philtrum. The surgeon creates a similar pattern of excision and arc of advancement on the contralateral lip. Following excision and minor undermining, the flap is advanced superiorly, thus recreating the natural contour of the upper lip vermillion. This is not an advisable repair in patients with a short upper lip, as it may diminish the vertical height of the lip. As with a mucosal advancement of the upper lip, the gull-wing flap can expose a more pink vermillion and lead to scaling for a period of time.



Figure 40-41. Gull-wing flap for closure of a philtral wound at the lip margin. (A) Wound of the Cupid's bow with a gull-wing flap designed. (B) The repair has been incised and elevated. (C) Immediate closure with restoration of the Cupid's bow. (D) Final result at 1 year. (Used with permission from Dr. Todd Holmes).

Opposing island pedicle flaps

Opposing bilateral island pedicle flap advancements can repair moderate wounds of the cutaneous lip and vermillion border that do not involve significant muscle loss.³ First, the mucosal island is elevated and advanced, carefully matching the vermillion border bilaterally. The cutaneous island is then advanced inferiorly to match and meet the mucosal island. While this repair is technically more challenging than a lip wedge, it preserves the perioral muscular band, eliminates the potential for microstomia, and nicely recreates the vermillion border. Because the restrictive tensions on both flaps and their postoperative contractile forces are symmetrically opposed, the vermillion border remains where it is placed at the time of surgery. The overall result is often outstanding (Fig. 40-42).



Figure 40-42. Opposed island flaps for repair of an upper lip marginal wound. (A) Operative wound and planned island flaps (one cutaneous, one mucosal). (B) The islands have been elevated and sutured into place. (C) Final repair at 6 months.

Philtrum and central upper lip

The central upper lip and philtrum are among the most challenging areas to repair in an aesthetic manner. The philtrum is bordered by vertical columns and the Cupid's bow, at least in younger patients. Cupid's bow itself has an "M" shape with two prominent vertical tips separated by a concave bow. The appearance of the Cupid's bow is much that of a suspension bridge. The ability to recreate this unit can be limited by multiple factors including the size of the upper lip and the extent and asymmetry of an operative wound.

Small and moderate wounds of the philtrum that are deemed worthy of repair require creativity and pose a reconstructive challenge. Wounds which bridge one of the philtral columns are often best reconstructed with a sizeable advancement flap which extends as a crescent around the nasal ala. Wounds that are located near the vermilion and are symmetric above the Cupid's bow may be repaired with a superiorly based island pedicle

advancement flap.¹⁷ This type of repair assumes a relatively substantial vertical component to the upper lip, as a short upper lip does not offer an adequate reservoir of tissue to accomplish this reconstruction. Central wounds that equally extend onto the vermilion and cutaneous lip are suited to opposing cutaneous and mucosal island flaps (Fig. 40-43). When the operative wound encompasses much of the philtrum, the most suitable repair may be to enlarge the wound to the entire subunit and perform a full-thickness skin graft.

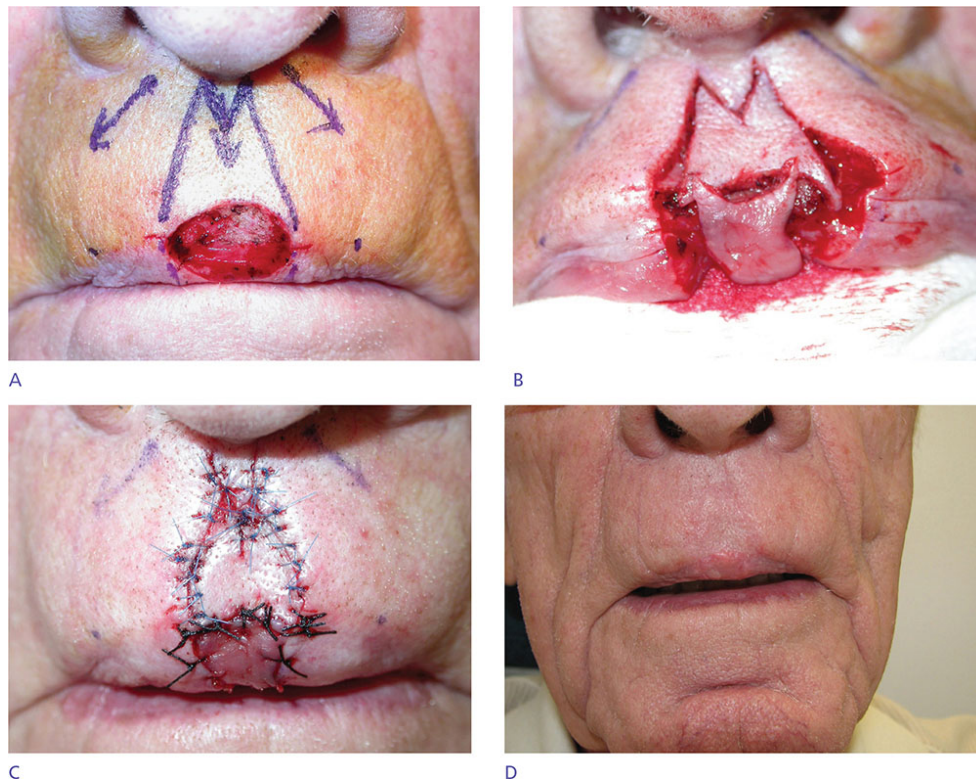


Figure 40-43. Cutaneous and mucosal island flaps to repair a philtral wound. (A) Wound of the philtrum with island flaps designed from philtral skin and mucosa. (B) The two flaps are elevated and meet at the vermilion border. (C) Immediate repair. (D) Final closure at 1 year.

LARGE UPPER LIP WOUNDS

Large, full-thickness wounds of the central upper lip present a distinct repair challenge. Failure to close such wounds with care—such as just doing a large lip wedge—will lead to microstomia and a fish-mouth deformity. In the past such wounds have been reconstructed with large circumoral flaps

analogous to a Karapandzic flap or with bilateral nasolabial flaps. Often preferable to such repairs are modified unilateral or bilateral crescentic advancement flaps or Abbe–Estlander variants. If just the philtrum is absent and the wound is approximately 25% of the upper lip, an Abbe flap from the lower lip can be suitable. This Abbe variant must be harvested laterally and does lead to some lower lip asymmetry. An alternative repair is a symmetric bilateral crescentic advancement.

Abbe–Estlander Flap

Large defects of the upper lip with substantial loss of lip margin present a reconstructive challenge. While large bilateral flaps can be used to accomplish closure of such wounds, a lip-sharing flap is often suitable.^{18–21} The appropriate wound for an Abbe flap is one that is broader than what would be reasonable for a lip wedge, and this usually corresponds to a wound of somewhat over $\frac{1}{3}$ of the upper lip, but not more than $\frac{1}{2}$ to $\frac{2}{3}$ of the upper lip. Because a lip-sharing flap presents difficulty with nutrition, other options should be investigated first. The lower lip should be examined for suitability. Ideally the patient has a wider, rather than a narrower oral aperture.

To perform an Abbe flap the operative wound is triangulated as a lip wedge and the edges are squared to receive the flap. The Abbe flap is designed medial to the operative wound if feasible and is drawn as a match to the upper lip wound with just a slight undersizing being reasonable in many cases. The flap is then fully incised as a wedge, leaving the superficial orbicularis oris muscle band and the labial artery as a pedicle. Failure to include a reasonable muscle pedicle will lead to venous congestion and can cause flap failure. The lower lip is closed as a lip wedge, and the upper lip is closed in a multilayer fashion starting with the mucosa. Matching up the vermillion border can be challenging. The muscle layer of orbicularis oris should be carefully reapproximated at closure.

The pedicle should be left in place for at least a week, and usually 2 to 3 weeks prior to flap division. At division, the labial artery has often miniaturized; frequently, only little bleeding is encountered. As the flap matures it will often pincushion and may have a bulky appearance, even with proper design and execution. Over 6 months to a year the flap will usually

reinnervate, first developing sensation and then motor function. Within a year, the reconstructed lip is usually fully functional.

Full-thickness crescentic advancements

Large wounds of the central or off-center upper lip can be repaired by a modification of the crescentic advancement flap. If the wound is of modest size and is off center, a unilateral crescentic advancement can suffice. The wound is squared off and excised full thickness to the gingival sulcus. The excision is carried around the ala laterally as a partial-thickness excision that preserves neurovascular integrity. The mucosa is incised as well, allowing for sufficient flap mobility. The lower portion of the wound is closed as a wedge with reapproximation of all lamellae; the upper portion is closed as a crescentic advancement.^{4,22} If the wound is large and central in location, bilateral rotations may be performed²³ with crescents around each nasal ala. Large wounds of the central upper lip can be repaired in this manner, with preservation of neurovascular anatomy and functional restoration of the oral sphincter.

LOWER LIP RECONSTRUCTION

Vermillion defects and shallow wounds

Mucosal advancement

Small to moderate defects of the lower lip vermillion heal well by second intention. Larger wounds are common, and may be bordered by extensive actinic cheilitis. In such cases, removal of the entire remaining lower lip vermillion may be suitable. Even then, second intention healing can offer excellent results, though the process may be more prolonged than some patients are willing to tolerate. In that event, or for other reasons, a mucosal advancement flap can be employed.²⁴ The mucosal advancement takes advantage of the loose flexible nature of the mucosa and submucosa of the lower lip (Figs. 40-44 and 40-45). The flap is elevated in the submucosal plane down toward the gingival sulcus. The dissection plane lies between the muscle and the submucosal glands. Larger branches from the

inferior labial arteries should be teased away by blunt dissection. If transected, they may require ligation. Bleeding from the perforators of the orbicularis oris can be reliably controlled by electrocoagulation. Any traumatized submucosal glands should be removed.



A



B



C

Figure 40-44. Mucosal advancement flap. (A) Operative wound following removal of a broad superficial squamous carcinoma. (B) Mucosal advancement at the time of suturing. (C) Result at 6 months with normal form and function.



Figure 40-45. Mucosal advancement flap. (A) Extensive actinic cheilitis. (B) Mucosal advancement flap in progress elevated meticulously above the musculature and as far toward the gingival sulcus as needed in order to advance under little tension. (C) Immediate closure. (D) Closure at 2 months. Notice that the lip is a bit pinker than the native vermillion.

Even a well-undermined mucosal advancement flap will usually advance under some tension. As soon as the flap will close readily, undermining may cease. In many cases, the flap does not require undermining down to the gingival sulcus, and closure may be feasible in older patients with relatively limited undermining.²⁵ It can be a challenge to place deep or buried sutures from the advancing margin to the cutaneous lower lip border, and in many cases a set of soft, braided simple interrupted surface sutures will suffice to close the wound. Deep sutures may cause suture reactions and may provide more trouble than benefit. The advanced flap quickly anneals to the underlying orbicularis oris and wound separation at suture removal is rare.

Mucosal advancements cause wet mucosa to be exteriorized. This tissue may appear redder than the patient may expect, and will often produce a dry scale for a prolonged period of time. Some patients complain that the advanced wet mucosa can feel chronically “sticky” against the upper lip. Because of back-pull tension, lower lip mucosal advancements almost never

completely re-form the fullness and convexity of the original lower lip. Vermillion foreshortening almost always occurs to a greater or lesser extent. In males, this can result in vertical protrusion of whiskers that irritate the upper lip. This never happens with second intention healing of an entire lower lip. These expected results should be discussed with the patient preoperatively.

Nasolabial flaps

Broad, modest-depth wounds of the mid to lateral lower lip which do not involve muscular loss may be repaired with either single-staged (Fig. 40-46) or two-staged (Fig. 40-47) nasolabial flaps. The flaps are inferiorly based and elevated down to and lateral to the lateral oral commissure. They may be elevated in the mid subcutis and remain viable with appropriate thinning. Historically such repairs were often tube-like, creating a rubbery lip, but with attention to detail the result can be aesthetic and functional. Specifically the flap must be adequately thinned and the recipient wound edges should be suitably undermined. Tacking the flap to the base of the operative wound may be of benefit. If the wound is part mucosal and part cutaneous, the mucosal lip may be advanced outward, although skin placed into the mouth as replacement for the vermillion will often mucosalize with time and provide a reasonable vermillion approximation. Given that such wounds are often very broad, the small cosmetic change is less noticeable.



Figure 40-46. Single-staged nasolabial flap reconstruction of a broad lower lip wound. (A) Large wound of the lower lateral lip. (B) Planned nasolabial flap reconstruction. (C) The flap is elevated in the subcutaneous plane. (D) With closure of the cheek wound along the nasolabial fold, the large banner flap transposes into place under no tension. (E) The flap has been sutured into place and tacked to the base of the operative wound. (F) Final result at 6 months.



Figure 40-47. Two-staged nasolabial transposition flap for repair of a lower lip wound. (A) Operative wound. (B) Plan for interpolated nasolabial flap. (C) Flap at suturing. (D) Mature flap at 3 weeks. (E) Immediate result. (F) Flap at 6 months. There is slight neovascularization, but the flap is aesthetic and functional, and the oral aperture has not been altered or foreshortened. (Used with permission from Dr. Todd Holmes).

Two-staged nasolabial flaps allow for somewhat more tailoring of flap thickness as they rotate and transpose into place under almost no tension. This repair is analogous to the upper lip two-stage transposition banner flap. The suitable wound is a broad wound without muscular involvement in

which a skin graft would be unaesthetic and the very extensive procedures described below are unwarranted.

Deep wounds with oral incompetence

Lip wedge

Moderate wounds approaching 25% of the lower lip which involve the loss of muscle are suitably repaired with a full-thickness lip wedge.²⁶ The method of performing the lip wedge is similar to that of the upper lip wedge, but unlike the upper lip wedge, the lower lip should always be excised full thickness and repaired in a simple, multilaminar manner (Fig. 40-48).

Whether or not a lower lip wedge will be successful depends on the innate properties of the oral aperture in a given individual. In patients with relative microstomia and a lack of mobility, other repairs may be more suitable. The scar from a lower lip wedge tends to be more visible than that resulting from an upper lip wedge. However, a Z-plasty incorporated into the wedge is invaluable in that it reliably disguises the repair (Fig. 40-49A–F).

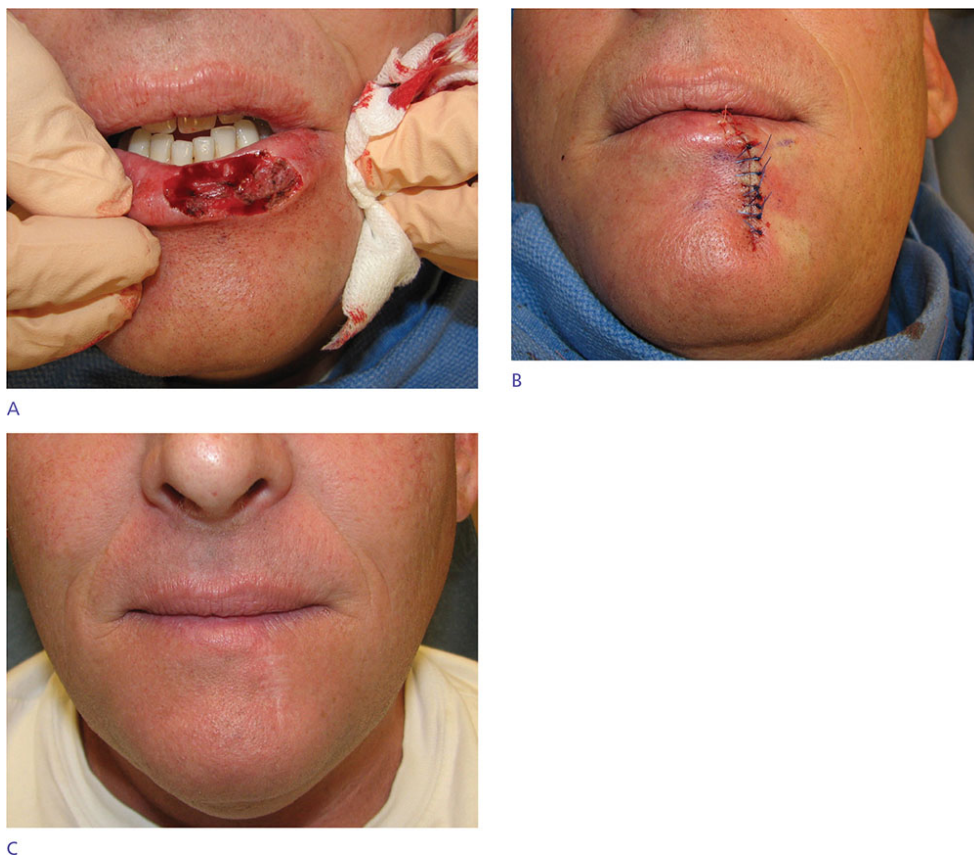


Figure 40-48. Lower lip wedge reconstruction. (A) A lower lip wound involves mucosa, skin, and muscle. (B) The wound is repaired as a full-thickness wedge. (C) Repair at 6 months. Lower lip wedge scars tend to be slightly more visible than upper lip wedge repairs.

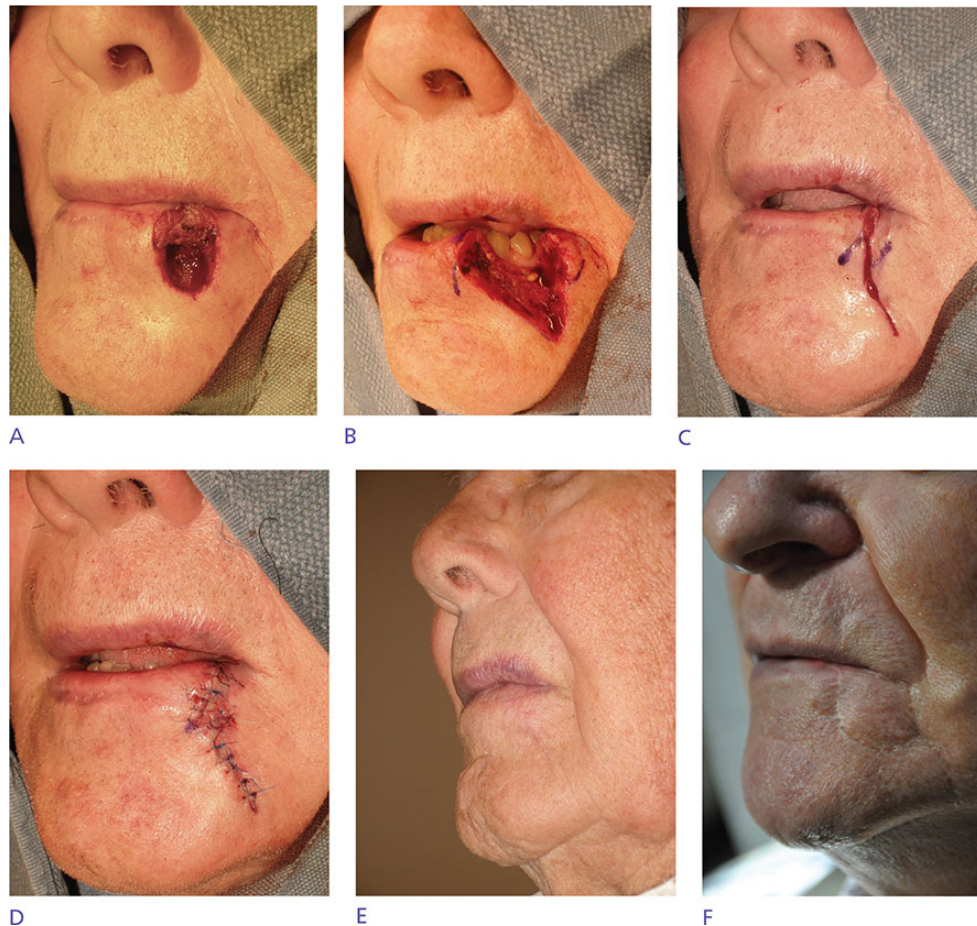


Figure 40-49. (A) Large, deep surgical defect of lower lip. (B) Wedge triangulation of the wound. Note, excision of mucosa is not extended to labial gingival sulcus. (C) Wedge reapproximated and Z-plasty designed. Note how reapproximation results in trigone deformity at vermilion border. (D) Executed Z-plasty corrects trigone deformity. (E) Final outcome demonstrates that a Z-plasty eliminates the trigone deformity and disguises the scar over the subvermillion convexity. (F) Compare and contrast the final outcome of a very similar reconstruction without the Z-plasty. Here the trigone deformity is blanched, but the vermilion border deflection is discernible.

Advancements

Larger wounds of the lower lip may be repaired with unilateral or bilateral advancement. Large advancements are then designed with a curvilinear sweep around the mental crease. A staircase design has been advocated²⁷ but a simpler arciform lower limb usually suffices with a dog ear removed laterally as needed. A benefit of this type of advancement is that as the flap is pulled medially, it rides up on the mental crease and supports the newly reconstructed lower lip. While the defect is often sizeable, it is often extended to the mental crease inferiorly and to the gingival sulcus as a

squared-off defect (Figs. 40-50 and 40-51). This allows for easier flap motion. Alternatively, if the wound is wide and of only modest depth, a partial-thickness bilateral advancement flap can be combined with a mucosal advancement flap (Fig. 40-52). A frequently discussed repair in the plastic surgery literature is the Webster–Fries method, in which larger wounds are repaired with bilateral advancements which extend the upper limbs of the flap through the oral commissure and out onto the cheek, where vertical standing tissue cones are removed lateral to the inferior nasolabial folds. This type of repair produces a suitable functional result but leads to alteration of the oral commissure with the potential for a resultant “Joker” appearance.²⁸ In most cases, such larger wounds are repaired with a Gilles fan flap or a Karapandzic flap.

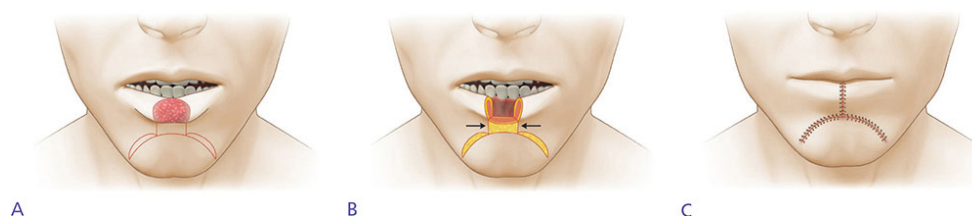


Figure 40-50. Bilateral advancement/crescentic rotation repair of the lower lip. (A) Diagrammatic representation of a mid-lower lip wound with planned bilateral crescentic advancements. (B) Bilateral crescentic rotation flaps have been designed, and the wound has been made full-thickness to facilitate closure. (C) As the flaps advance and rotate into place the mental crease provides vertical support.



A



B



C



D



E



F



G

Figure 40-51. Unilateral advancement to repair a wound of the lower lip. (A) Operative wound of the lower lip. (B) The lip wound has been squared off full-thickness. (C) The lower incision around the mental crease is incised through and through. (D) The mucosa is closed. (E) Completed repair as a multilayered closure. (F) Restoration of oral competence with the mouth opened. (G) Final result at 2 months.



Figure 40-52. Bilateral advancement combined with mucosal advancement. (A) Broad, modest-depth wound of the lower lip. (B) Bilateral crescentic advancement flaps designed. (C) Elevation of flaps just above muscle. (D) Immediate result. The advancements have been used to repair the cutaneous lip and the mucosa has been advanced to recreate the vermillion.

Gilles flap

The Gilles fan flap is a unilateral full-thickness rotation flap used to repair larger wounds of the lower lip.^{29,30} Appropriate wounds are deep, full-thickness wounds with oral incompetence that comprise about one-third of the lower lip and are therefore not amenable to reconstruction with a lip wedge. In the past such wounds were frequently closed with an upper-to-lower lip Abbe flap, but most surgeons will no longer sacrifice the upper lip to repair a wound of the lower lip. Instead, a large, full-thickness flap with components of rotation and transposition can be designed around the oral

commissure. The technique of flap elevation and motion are similar, albeit not identical, to the Karapandzic flap as described below.

Karapandzic flap

Large lower lip wounds may require an extensive circumoral reconstruction known as a Karapandzic flap. Appropriate wounds are large, deep defects with oral incompetence and which comprise approximately half or even more of the lower lip horizontal dimension. The Karapandzic flap involves the rotation of two flaps with a reduction in the oral aperture, a sharing of horizontal loss between the upper and lower lips, and a reset of the lateral oral commissures.^{31,32}

The flap design and execution are of paramount importance, as a failed Karapandzic flap may have drastic consequences. First, the defect is squared off full thickness down to the gingival sulcus and inferiorly toward the mental crease. The bilateral flaps are then designed laterally in sweeping arcs around the oral commissure. The flap design completely ignores the nasolabial folds. The width of the flap is equal at all points and should approximate the vertical height of the lower lip to the gingival sulcus/mental crease.

Complete anesthesia should be achieved by bilateral mental blockade and bilateral infraorbital block along with local anesthesia of the lateral tissues. The initial incisions are made to deep adipose, following which hemostasis is achieved. The superior and lateral incisions are made down to the musculature toward the modiolus, but not through these deeper tissues, thus protecting the innervation and vascular supply to the mouth. The repair is made full thickness as far laterally as is needed to advance the wound edges together under reasonable tension. The mucosa may be incised internally some distance to mobilize tissues without having to incise through the deeper tissues at the corner of the mouth. Historically the vessels, nerves, and muscles were carefully dissected out and maintained. In practice, it is safer just to avoid extending the deep portion of the excision this far laterally.

The Karapandzic flap is an extensive reconstruction and should not be undertaken without substantial operative experience and a careful review of the literature. A failed large oral reconstruction has devastating aesthetic and functional implications and may require multiple revisions.

WOUNDS OF THE ORAL COMMISSURE

Large wounds of the oral commissure can be closed directly, but the asymmetry created is substantial, the scar extending out onto the cheek is distracting, and it is challenging to recreate the normal angle of the mouth with such a repair. A useful alternative repair is to modify the Abbe flap into a single stage, using either upper or lower lip to recreate the commissure. This miniature Abbe flap is a straightforward approach that results in a highly functional closure ([Fig. 40-53](#)).

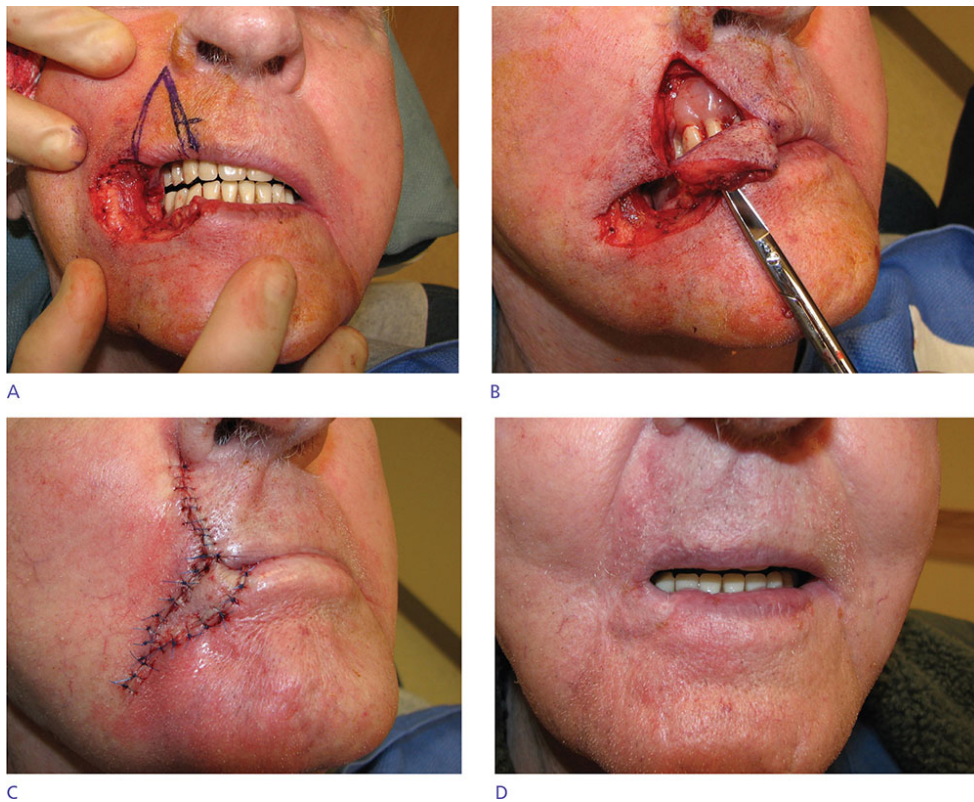


Figure 40-53. Modified single-staged Abbe flap for reconstruction of a wound of the lateral commissure. (A) Deep wound of the corner of the mouth with planned Abbe flap. (B) The flap is elevated and survives on a small medial pedicle. (C) The defect is closed. Because the flap is elevated immediately adjacent to its insertion point the closure is a single-staged procedure. (D) Result at 6 months. If desired, a right lateral commissuromplasty could be performed for greater symmetry.

CONCLUSIONS

The lips represent a challenging reconstructive location, as both aesthetic and functional compromise may result from subpar repairs. A thorough understanding of lip anatomy is a critical prerequisite prior to undertaking any reconstruction in this complex area. While the lips may provide a forgiving environment vis a vis scarring, the functional implications of imprecise repair choices, coupled with the importance of recreating the white line, particularly in younger patients, means that this anatomic location should be approached with respect and caution. That said, the chance to vastly improve the quality of life of patients with defects in this location presents a significant opportunity for the experienced dermatologic surgeon.

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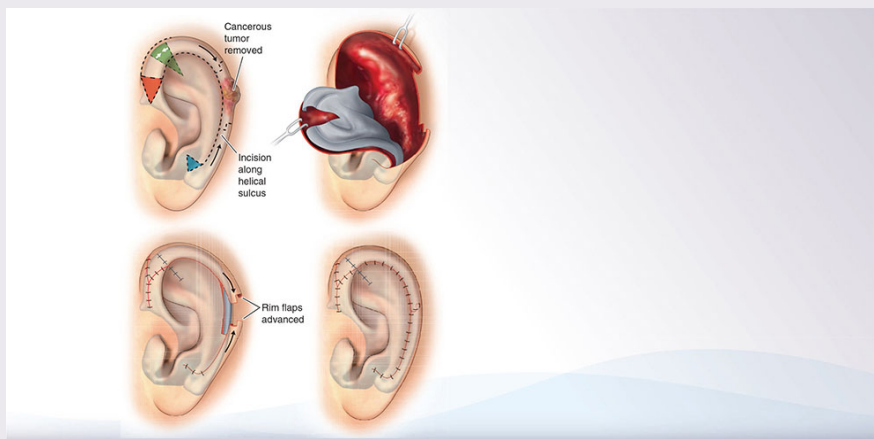
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CHAPTER 41 Reconstruction of the Ears

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SUMMARY

- Goals of auricular reconstruction include maintaining a patent external auditory canal and restoring the projection and complex contours of the external ear.
- The ear has highly variable topography but consistent silhouette and positioning.

Beginner Pearls



- Canalicular cartilage creates the lateral external auditory canal (EAC) and must remain patent.
- Since the EAC is only 7 mm in diameter, any reduction in circumference from scarring can diminish hearing.
- Because the thin skin of the anterior ear adheres to the cartilage, flaps may be used to mobilize the thicker, looser skin of the helical rim and posterior ear.

Expert Pearls



- The oval contour of the free margin of the helical rim and earlobe, more so than the complex topography of the anterior ear, influences perception of an ear as normal.
- Minor variations in ear height or topography rarely impact cosmesis.
- Helical rim advancement flaps are workhorse reconstructions for full-thickness, short helical rim defects.

Don't Forget!



- Deep defects of the concha and antitragus can be reconstructed with an island pedicle that pulls skin from the postauricular sulcus and mastoid areas into the defect.
- Chondrocutaneous advancement flaps are useful for even large defects, relying on a broad pedicle derived from the posterior auricular skin.

Pitfalls and Cautions



- Always take time to assess whether a patient regularly wears glasses, as recreating a convenient and comfortable eyeglass resting place is important for patient comfort and convenience.
- Meticulous suturing is helpful to avoid wound edge inversion along the helical rim that could otherwise lead to clinically obvious notching.

Patient Education Points



- Always gauge a patient's willingness to undergo and recover from an extensive procedure *before* it is initiated.
- Some patients may prefer a small partial closure to a more involved and much larger flap.
- Warn patients against having their glasses repeatedly rub against nascent surgery sites in the immediate postoperative period.

Billing Pearls



- Random pattern single stage flaps on the ears are coded with 14060 or 14061, and these codes include the excisional component; it is not appropriate to bill both an excision and a flap repair code simultaneously, except for Mohs excision codes.
- When coding a flap, graft, or linear repair, medical necessity is the ultimate arbiter of appropriateness.

CHAPTER 41 Reconstruction of the Ears

INTRODUCTION

The highly contoured external ear and external auditory canal (EAC) collect and direct sound waves toward the tympanic membrane (TM).¹ Visibly misshapen or malpositioned ears can negatively impact psychosocial health.²⁻⁴ Goals of ear reconstruction include maintaining a patent EAC and restoring the projection and complex contours of the external ear. Several key principles help to preserve and restore appearance and function for each step of the reconstructive ladder.

KEY ANATOMIC PRINCIPLES FOR AURICULAR RECONSTRUCTION

This section will focus on key anatomic principles that require consideration for every ear reconstruction.

The ear has highly variable topography but consistent silhouette and positioning

The external ear derives from the first and second branchial arches and grows until the age of 6. An adult ear is approximately 6 cm in height and attaches to the mastoid by muscles and ligaments with a posterior vertical tilt of 15 to 20 degrees.^{5,6,7} The concha cavum braces the external ear to the mastoid bone. Three auricular muscles (superior, anterior, and posterior) and

their corresponding ligaments further support the attachment of the ear to the skull. Pulling the ear forward stretches the posterior auricularis muscle in a clearly visible band that spans the postauricular sulcus.⁸ The oval-shaped outer helical rim usually projects no more than 2 cm from the temporal scalp.⁹ The cartilaginous upper portion of the pinna usually projects more than the freely hanging, fibrofatty earlobe.¹⁰

The elastic fibrocartilage substructure of the ear creates a highly irregular topography that funnels sound waves to the TM. The cartilage of the external ear is approximately 1 to 3 mm thick and has a nautilus shape with varied topography that shows through the thin, firmly affixed skin. The tight skin covering the anterior auricular cartilage is approximately 1 mm thick and has scant subcutaneous fat, while the looser, thicker posterior auricular skin has a buffer of subcutaneous fat between the dermis and perichondrium.⁵ Consequently, the posterior skin is easier to undermine and stretch.

Canalicular cartilage creates the lateral EAC and must remain patent

The EAC sits in the bowl of the pinna inferoposterior to the tragal cartilage, and connects the external and middle ear. The canal originates posterior to the condyle of the mandible and parotid gland and extends approximately 2.5 cm from the conchal bowl to the TM. Its lateral third is a cartilaginous extension of the concha, while the medial two-thirds are formed by the temporal bone.¹¹ Skin of the EAC is thin, adheres tightly to the perichondrium, and secretes cerumen that prevents maceration of the canal. Since the EAC is only 7 mm in diameter, any reduction in circumference from scarring can diminish hearing.

The tragal cartilage and tympanomastoid suture provide reliable landmarks for the facial nerve

The facial nerve exits the skull base through the stylomastoid foramen and enters the parotid gland, where it divides into temporofacial and cervicofacial divisions that innervate the muscles of facial expression. Resection of deep periauricular or canalicular tumors may injure the nerve,

potentially resulting in ipsilateral facial paralysis. Four commonly used landmarks to identify and protect the facial nerve during surgery include the posterior belly of the digastric muscle (PBDM), tragal cartilage pointer, junction of the bony and cartilaginous EAC, and tympanomastoid suture (TMS).¹²

Of these markers, the TMS lies closest to the nerve, approximately 2.5 mm lateral to the main trunk. Although the tragal cartilage is flexible and subject to retraction, it remains one of the most reliable and frequently used landmarks to identify the main trunk of the facial nerve. The tragus is located just below the crus of the helix anterior to the concha, and its anterior edge has a bluntly pointed shape on its medial aspect.¹³ The facial nerve lies approximately 1.0 to 1.5 cm deep and slightly anterior from this tragal pointer.¹⁴ The facial nerve is found 5 to 8 mm superior to the PBDM and approximately 1 cm inferior to the junction of the bony and cartilaginous EAC.

The vascular supply of the ear is reliable and consistent

Two branches of the external carotid artery, the posterior auricular artery (PAA) and the superficial temporal artery (STA), supply blood to the posterior and anterior surfaces of the pinna, respectively.¹⁵ Auricular veins correspond to the arteries of the ear.

The PAA is a small branch of the ECA that arises just superior to the occipital artery. It ascends posteriorly between the parotid gland and styloid process and the groove between the auricular cartilage and mastoid process. The course of the PAA is predictable. It lies 0.3 cm anterior to the mastoid deep to the earlobe in the postauricular sulcus. As it ascends in the sulcus it is found 1.2 cm posterior to the EAC and then 2.4 cm posterior to the superior helical attachment to the scalp.¹⁶ Above the mastoid process the PAA gives off occipital and auricular branches. These vessels provide a robust supply for random and axial flaps behind and above the ear.

The STA is a terminal branch of the external carotid artery and begins in the parotid gland behind the mandible. The vessel is approximately 2.5 mm in diameter and lies 1.5 cm in front of the tragus, where its pulse may be

palpated.¹⁷ After it crosses over the zygomatic process, it divides into the frontal and parietal branches at the level of the upper pinna. Prior to its division the STA delivers auricular branches that supply the helix, tragus, antihelix, and scapha. The STA and its perforators provide a reliable blood supply for numerous flaps useful for ear reconstruction.

Principles of reconstructive design

Maintaining patency of the EAC is critical for hearing. Although their lateral location makes it difficult to view both ears simultaneously, conspicuous changes to the ear include helical rim notching, anteversion of the pinna, or protrusion of the ear greater than 2 cm from the temporal scalp. The following reconstructive principles will help to preserve function and form:

1. *Preserve EAC patency.* Scarring from defects of the tragus, concha, or EAC may occlude the canal. The risk for contraction and stenosis increases when the cartilaginous canal has been removed. Small reductions in the radius of the EAC can dramatically restrict sound transmission (Fig. 41-1), so reconstruction should aim to preserve full patency.



A



B

Figure 41-1. (A) Composite defect encompassing EAC, concha, and antitragus. (B) Three months postoperatively after repair with FTSG. Graft pincushioning reduced the EAC circumference and impaired patient hearing.

2. *Maintain helical rim and earlobe contour.* The oval contour of the free margin of the helical rim and earlobe, more so than the complex topography of the anterior ear, influences perception of an ear as normal.¹⁸ Restoring and preserving the volume and contour of the free margin is important to avoid conspicuous notching (Fig. 41-2).

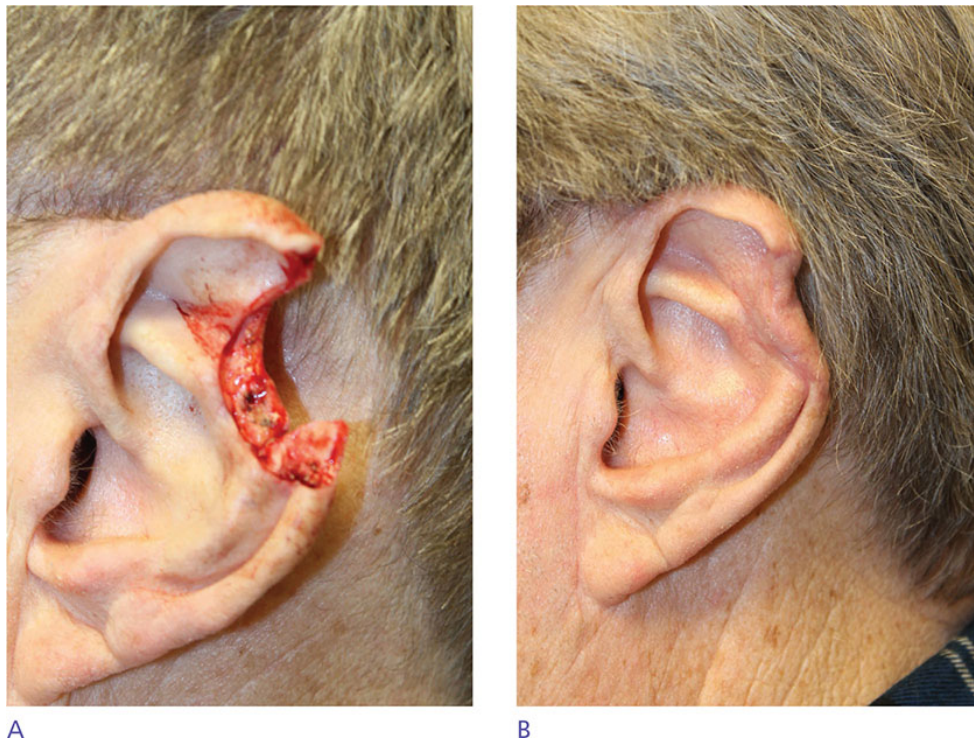


Figure 41-2. (A) Defect with significant helical rim cartilaginous loss. (B). Repair with notching that failed to restore true convexity.

3. *Restore projection of the pinna.* Simultaneous viewing of both ears is difficult, so minor variations in ear height or topography rarely impact cosmesis.¹⁹ However, changes in projection of the ear relative to the scalp may be conspicuous (Fig. 41-3). Significant reductions in pinna height or shape may not support eyeglasses or hearing aids. Reconstruction ideally preserves the normal projection and height of the pinna, and leaves a sufficient shelf to rest eyeglasses.



Figure 41-3. (A) Lower ear defect encompassing numerous subunits. Unsuccessful reconstruction of this defect would leave a sharp demarcation in a free margin with altered projection from the scalp and neck. (B) Staged trilateral flap to create platform for earlobe. (C) Two months later, staged tubed flap. (D) Two months later, cephalic portion of tube sutured to lower helical rim. (E) Two months later, caudal margin of tube detached and flipped to recreate earlobe. (F) Final postoperative appearance.

RECONSTRUCTIVE APPROACHES

Second intention healing

Second intention healing predictably results in shiny scars that resemble the tight skin over the pinna.²⁰ The underlying cartilage resists contraction of shallow cutaneous defects. However, deep and broad wounds of the earlobe and helical rim may contract and disrupt the contour of the free margins.

Composite wounds involving skin and cartilage contract more and may change the shape of the ear, especially when the wound is near the helical rim (Fig. 41-4). Contraction from second intention healing of broad or composite defects of the EAC may cause stenosis.



Figure 41-4. (A) Broad antihelical defect allowed to heal by second intention. (B) Appearance 2 months postoperatively with displaced helical rim from wound contraction.

Wounds with intact perichondrium heal faster and have decreased risk for chondritis. Exposed cartilage devoid of perichondrium is prone to desiccation, infection, and necrosis.²¹ Full-thickness trephinations of exposed cartilage may reduce these complications by recruiting granulation tissue from the intact skin on the other side of the ear. Occlusive dressings, moisturization with petrolatum, and vinegar soaks or oral antibiotics may minimize chondritis.

Linear repair

Linear closures have a limited role in ear reconstruction due to the inelasticity of the thin, adherent skin and resistance from underlying cartilage.²² Fusiform closure of small defects of the looser, posterior auricular skin, and earlobe may be possible. However, closure tension may buckle the underlying cartilage or distort the free earlobe margin. Fusiform closures oriented parallel to the free margin may be possible for small helical rim defects in patients with especially loose or thick skin (Fig. 41-5). Increasing the length:width ratio of the fusiform closure to 5:1 is usually helpful to reduce standing cones and to preserve a natural helical rim contour (Fig. 41-6).



Figure 41-5. (A) Helical rim defect. (B) Linear repair. (C) Postoperative appearance.



Figure 41-6. (A) Helical rim defect design revealing elongated length:width ratio. (B) Linear repair with preserved convex contour.

Skin grafting

Skin grafting plays a large and versatile role in auricular reconstruction. Nearly any partial-thickness ear defect with preserved perichondrium is amenable to skin grafting (Figs. 41-7 to 41-9). Full-thickness skin grafts (FTSGs) have increased metabolic demand but provide greater volume, which may be desirable to restore contour of helical rim defects.²³ The pre- and postauricular skin folds are ideal donor sites for small FTSGs because of similar sun exposure, sebaceous gland density, and dermal thickness (Fig. 41-10). Postauricular donor sites may decrease operating time, since they do not require primary closure. Split-thickness skin grafting may be preferable if the blood supply at the base of broad wounds is tenuous (Fig. 41-11).²⁴



A



B

Figure 41-7. (A) EAC defect. (B) Immediate postoperative appearance.



A



B

Figure 41-8. (A) Conchal defect. (B) Two months postoperatively.



Figure 41-9. (A) Antihelical defect. (B) FTSG in place with quilting sutures to recreate the scaphoid fossa. (C) Two months postoperatively.

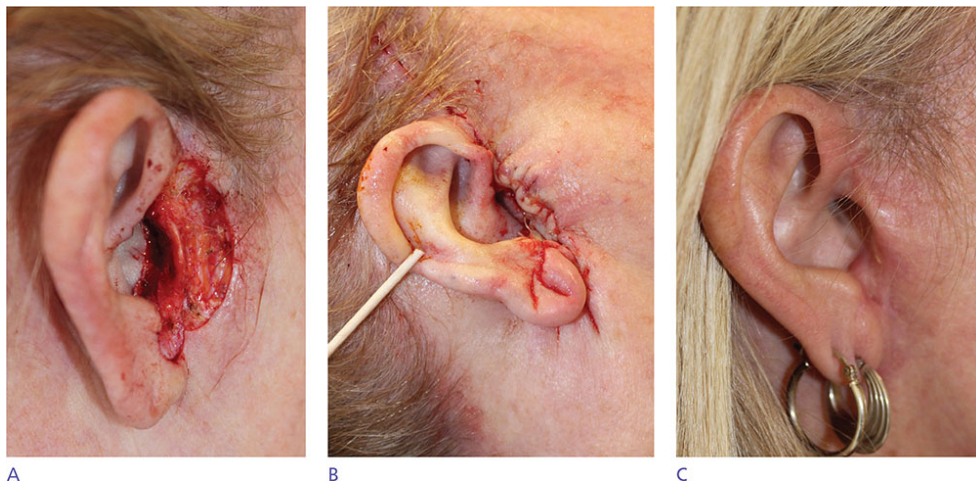


Figure 41-10. (A) Pretragal and EAC defect. (B) Preauricular skin advanced and redundant cones used for EAC graft. (C) Four months postoperatively.

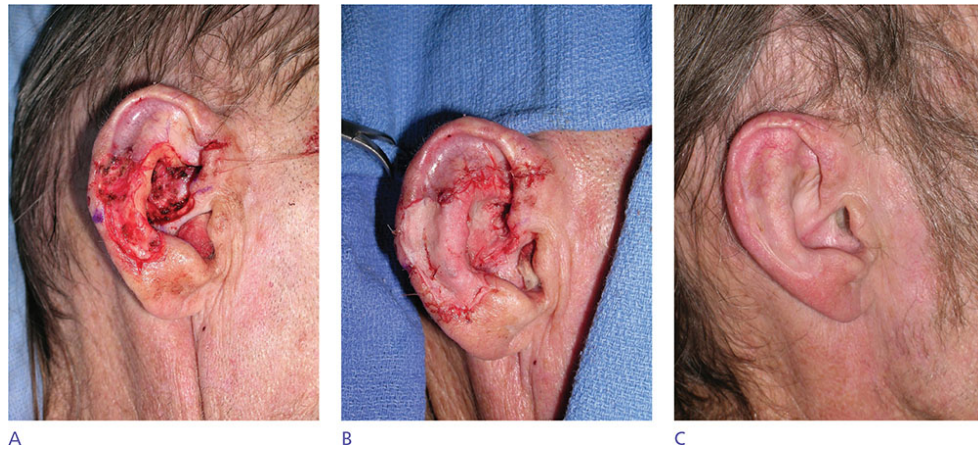


Figure 41-11. (A) Defect spanning antihelix and concha. Note that a window of cymba conchae cartilage devoid of perichondrium was excised to facilitate graft survival. (B) Split-thickness skin graft sutured to wound. (C) Eight months postoperative appearance with expected hypopigmentation of graft.

Grafts placed on wounds with insufficient blood supply or that do not conform to the complex topography of the ear have an increased risk of necrosis. Cartilage stripped of perichondrium will not adequately nourish a skin graft. One strategy to provide a vascularized wound bed is to cut a window of the stripped cartilage so that the graft can be sutured to the highly vascularized skin on the other side of the ear (Fig. 41-11A). Excising the cartilage of the concha and antihelix will rarely change the shape of the ear if at least 1 to 1.5 cm of the outer helical rim is intact. Air pockets between the graft and wound base will cause necrosis or infection. Quilting sutures and/or conforming bolster dressings eliminate this dead space and conform skin grafts to the concavities and convexities of the ear (Fig. 41-12).



Figure 41-12. (A) Numerous quilting sutures placed in center of full-thickness skin graft to minimize dead space from wound bed. (B) Xeroform bolster fixed to wound with through-through suture further ensuring contact between graft and wound bed.

Wedge repairs

Wedge repairs are useful to restore contour of full-thickness helical rim defects, ideally less than 1 to 1.5 cm in height. Wedge repair of taller rim defects may noticeably decrease the height of the ear. The wedge repair is analogous to one-half of a linear closure. Two arms of a triangular standing cone are drawn from the edges of the rim defect toward the center of the ear, where they converge at an angle of 30 degrees or less. The full thickness of the triangle, or “wedge,” is excised. On the pinna, the wedge includes the cartilage and skin (Fig. 41-13). On the earlobe, the wedge includes the skin and subcutaneous fat (Fig. 41-14). The first suture, or key suture, realigns the free edges of the wedge along the helical rim with everted edges to avoid notching. Buried sutures with the knots on the postauricular side reapproximate the cut edges of cartilage. Wide bites that grasp the dermis on one or both sides may be necessary to avoid tearing the cartilage. Anteversion or forward cupping of the ear may occur and can be minimized

by resecting star-shaped composite segments (Fig. 41-15), rather than the simple triangular wedge. After realigning the cartilage edges, the skin can be closed with a simple layer of running sutures.

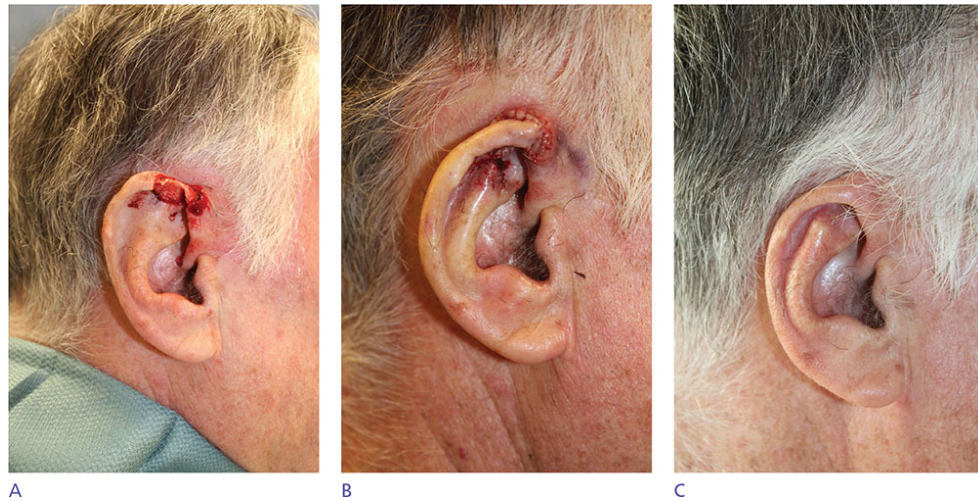


Figure 41-13. (A) Helical rim defect. (B) Wedge repair. (C) Two months postoperatively.

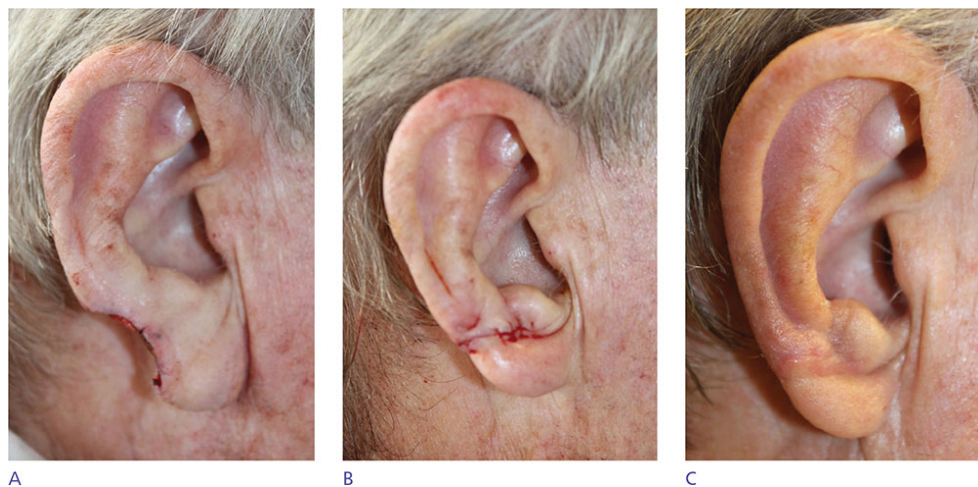


Figure 41-14. (A) Earlobe defect. (B) Wedge repair. (C) Two months postoperatively.

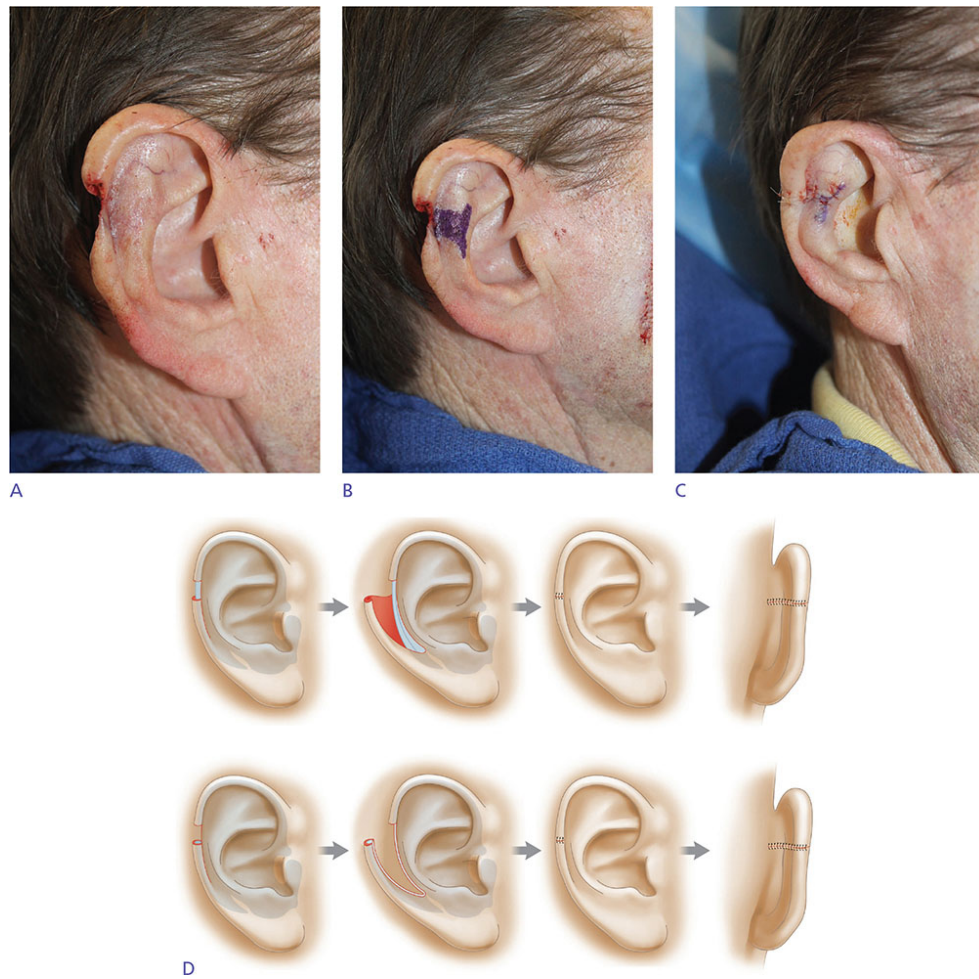


Figure 41-15. (A) Helical rim defect. (B) Star-shaped wedge design. (C) Wedge repair. (D) Illustration of the helical rim advancement flap.

Flaps

Because the thin skin of the anterior ear adheres to the cartilage, flaps may be used to mobilize the thicker, looser skin of the helical rim and posterior ear. Common examples on the ear include helical advancement flaps and V-Y island pedicle advancement flaps. Rotation flaps are infrequently performed on the ear.

Helical rim advancement flaps

Helical rim advancement flaps are workhorse reconstructions for full-thickness, short helical rim defects (usually less than 1.5 cm). These flaps recruit skin from the loose, mobile earlobe. The earlobe-based advancement

flap (ELBAF) incises a full-thickness tube of skin and cartilage along the scaphoid fossa from the lower margin of the defect to the earlobe (Fig. 41-15E).¹⁵ The tube may be widened at the earlobe to enhance the blood supply. The narrow tube contains STA branches that course through the earlobe and run superiorly along the helical rim. A buried suture along the leading edge of the tubular flap advances the flap superiorly and closes the helical rim defect. The vertical arms of the flap are closed in a layered fashion. Advancing the flap may cause tissue redundancy along the inner edge of the vertical arms, and the standing cone can be excised at the earlobe. The ELBAF design may be modified with a bilateral tubular advancement flaps along the helical rim above and below the defect. This bilateral design offers limited mechanical advantage, because the inelastic skin of the superior limb has limited mobility and causes cartilage buckling.

Another modification of the traditional helical rim advancement flap is the chondrocutaneous advancement flap (Fig. 41-16).²⁵ This flap also recruits skin from the loose earlobe, though the chondrocutaneous advancement flap has a broader pedicle derived from the posterior auricular skin. An incision is made from the inferior aspect of the helical rim defect along the scaphoid fossa to the earlobe through the anterior skin and cartilage. The postauricular skin is preserved and elevated immediately superficial to the cartilage on the posterior ear. A buried suture along the leading edge of the flap advances the flap superiorly and closes the helical rim defect. The vertical arm of the flap in the scaphoid fossa is closed in a layered fashion. Advancing the flap causes tissue redundancy along the inner edge of the scaphoid fossa, and a standing cone is excised at the earlobe. To avoid buckling when closing taller helical rim defects, removing a vertical strip of scaphoid cartilage may be necessary.²⁶ Closing larger defects predictably shortens the height of the earlobe (Fig. 41-17).



A



B



C

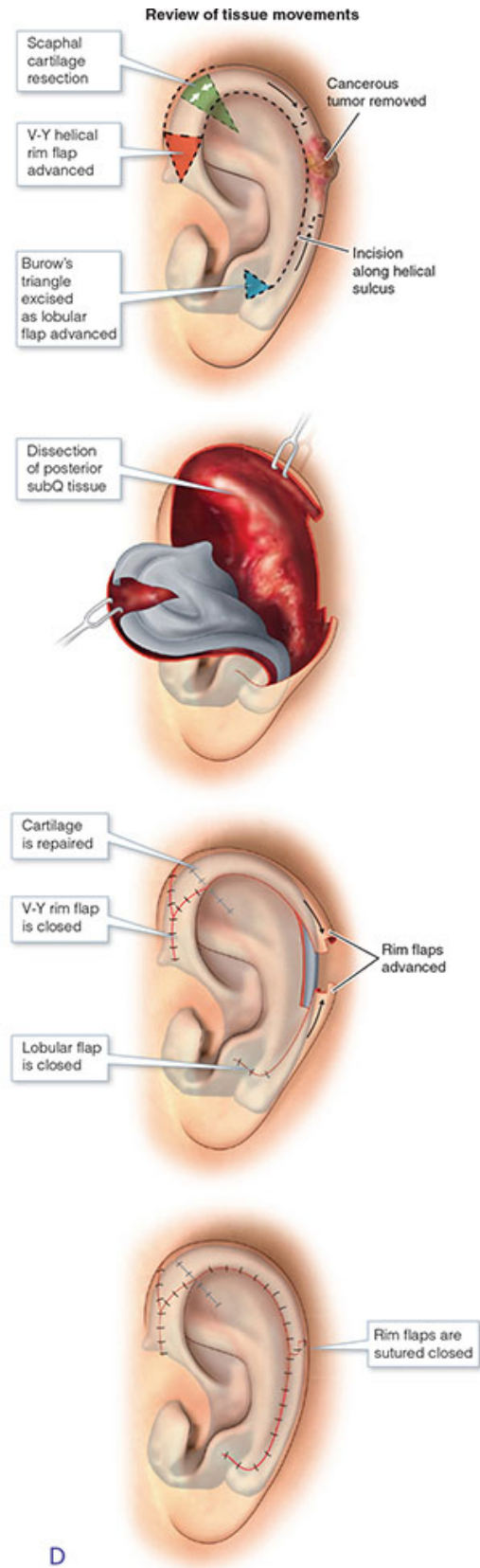


Figure 41-16. (A) Helical rim defect. (B) Chondrocutaneous advancement flap design that hides incision within scaphoid fossa. (C) Postoperative appearance. (D) Figure illustrating the chondrocutaneous advancement flap.



Figure 41-17. (A) Helical rim defect. (B) Chondrocutaneous advancement flap elevated off of cartilage framework. (C) Postoperative appearance. (D/E) Six-week postoperative appearance with frontal view revealing reduced earlobe height.

V-Y Island pedicle advancement flaps

Deep wounds located on the helical root (Fig. 41-18) and conchal bowl (Fig. 41-19) can be elegantly repaired with V-Y advancement flaps. Unlike other advancement flaps, the pedicle of V-Y flaps is perfused from a centrally located fasciocutaneous segment. This enhanced blood supply permits the flap to deliver thicker portions of tissue to the defect. The V-Y flap is designed by creating a triangular flap off of the defect toward the reservoir of

skin to be lifted. Incisions are carried through the skin to the fascia, creating an island. The flap is mobilized with circumferential undermining so the central 30% to 50% of the flap is tethered to the underlying tissue. The flap rocks forward toward the defect and should be sutured under minimal tension.



A



B



C



D

Figure 41-18. (A) Preauricular cheek defect. (B) Inferiorly based V-Y advancement flap design. (C) Postoperative appearance. (D) Three months postoperatively.

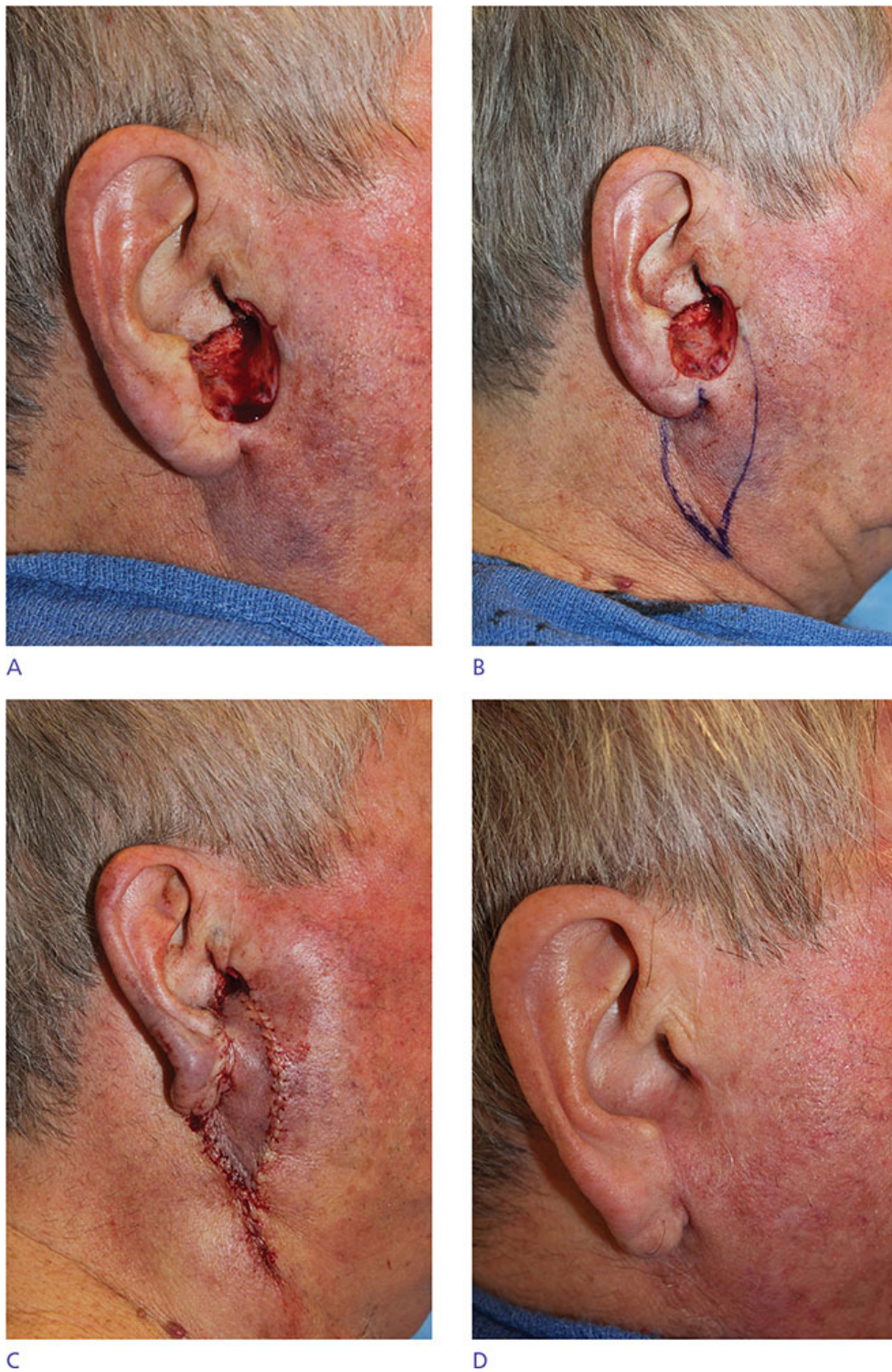


Figure 41-19. (A) Preauricular cheek and conchal bowl composite defect. (B) Inferiorly based V-Y advancement flap design. (C) Postoperative appearance. (D) Two months postoperatively.

Pull-through flaps

Deep defects of the concha and antitragus can be reconstructed with an island pedicle that pulls skin from the postauricular sulcus and mastoid areas into the defect (Fig. 41-20).²⁷ In order to mobilize tissue and minimize free margin distortion, the flap is measured exactly to the size of the defect. The medial aspect of the flap is positioned in the postauricular sulcus and provides both the blood supply and pivot point for the flap. After the flap is incised through the deep subcutaneous layer it is then undermined in this plane toward the sulcus, making certain to preserve soft tissue tethered to this pivot point. Next, a slit measuring the vertical height of the flap is created through the full thickness of skin (and cartilage if still intact) just lateral to the EAC. After meticulous hemostasis is obtained, the lateral edge of the mastoid skin is elevated, pulled through the full-thickness opening, and laid atop the defect. Cartilaginous grafts may be used under the flap to support the auricular framework if the defect extends closer to the helical rim. The secondary defect is sutured to recreate the postauricular sulcus and the flap may be secured to the defect with sutures. Patients may report a sensation of the ear being pulled back if the flap is used to cover a wide horizontal distance.

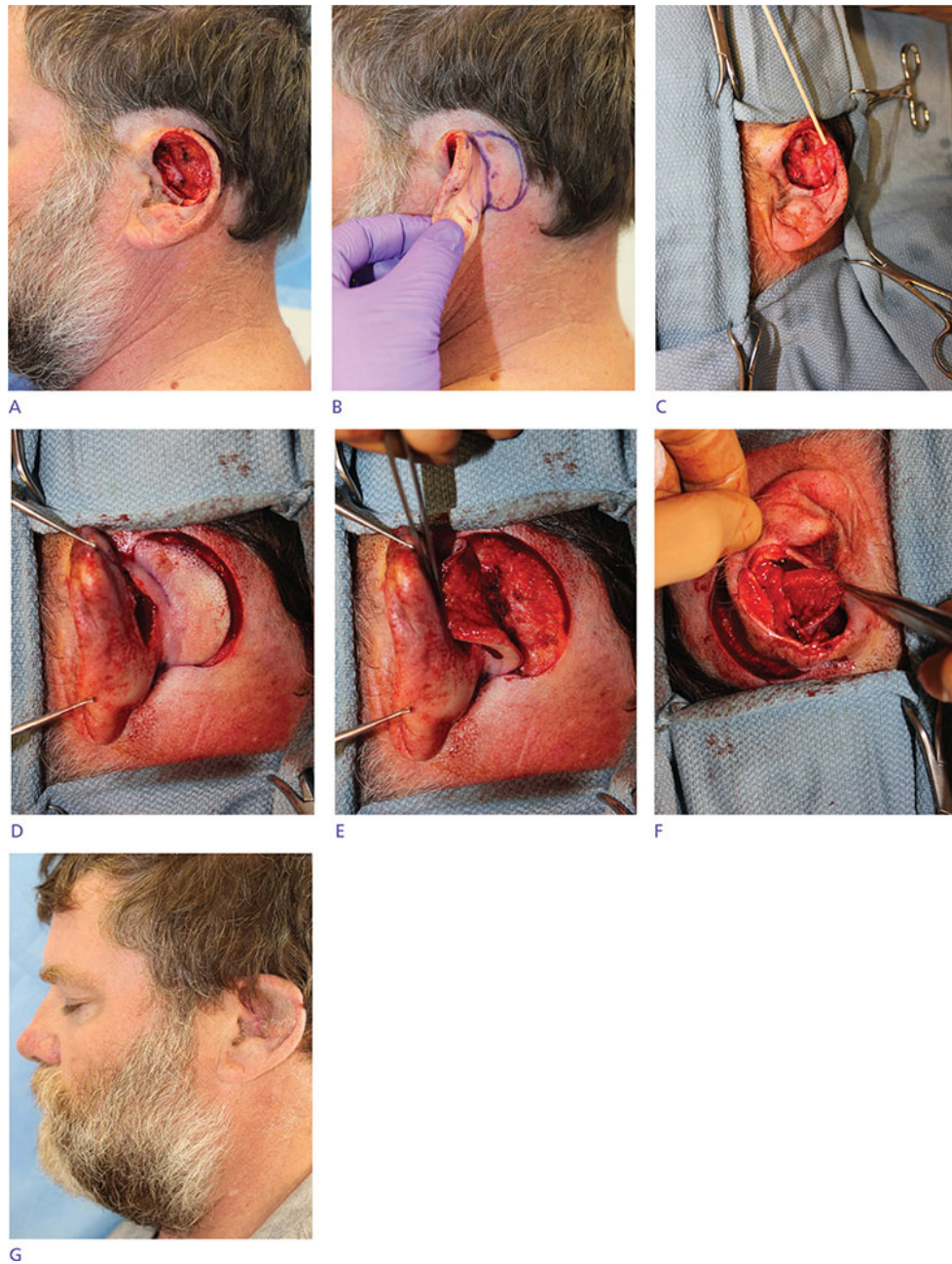


Figure 41-20. (A) Anterior auricular defect with absence of cartilage. (B) Pull-through V-Y flap design on postauricular sulcus. (C). Cartilage graft secured to anterior surface of ear for stabilization. (D) Pull-through V-Y flap incised. (E). Pull-through V-Y flap elevated. (F) Pull-through V-Y flap as it passes through full-thickness portal. (G) Two months postoperatively, note hairs from temporo-occipital scalp have been transferred to the ear.

Transposition flaps

Transposition flaps are useful when tension at the primary defect precludes linear closure or a sliding flap. They redirect tension away from the primary defect to adjacent tissue reservoirs. Since elevating and mobilizing the tight skin of the ear is usually not possible, transposition flaps of the ear must recruit skin from periauricular reservoirs. The skin of the mastoid scalp is relatively inelastic and contains a small zone of hairless postauricular skin; therefore, most transposition flaps of the ear recruit from the loose and mobile reservoir of preauricular skin. Regardless of the periauricular donor site, the transposition flap must cross either the deep postauricular sulcus or less prominent preauricular sulcus, which may result in tenting or contour deformity as the flap extends to the primary defect.

Banner flap

The elongated rhombic flap, also known as a Banner flap, is a workhorse repair for helical root and upper helical rim defects. This random pattern flap transposes skin with a similar color and texture match from the pre- or postauricular skin to the ear (Fig. 41-21). Perforator vessels from the STA or PAA supply these flaps.²⁸ A flap similar to the Dufourmental rhombic flap is drawn from the defect along the pretragal or postauricular crease.²⁹ The width of the flap and defect should match. As with other periauricular flaps, the Banner flap is elevated and undermined immediately above the SMAS. A larger length:width ratio risks ischemia, since the flap has a narrow pedicle. The key stitch, which bears the greatest tension, closes the donor site along the pre- or postauricular crease, and the flap is transposed with relatively low tension to the primary defect. Closing the donor site brings the beard or occipital hair closer to the pinna and may be a nuisance for patients to shave or trim.



A



B



C



D

Figure 41-21. (A) Helical root defect. (B) Superiorly based Banner flap design. (C) Postoperative appearance. (D) Two months postoperatively.

Chondrocutaneous transposition flap

Large full-thickness defects of the superior pinna can be repaired with a single-stage conchal bowl transposition flap (Fig. 41-22).³⁰ A branch of the STA courses along the crus of the helix superficial to the cartilage³¹ and is included in the narrow, mobile, and robust flap pedicle. The anterior skin and cartilage are incised nearly 300 degrees from the cymba conchae along the antihelical rim to the inferior aspect of helical crus. The incision spares the EAC and preserves the entire helical crus, which forms the flap pedicle. The outer curve of the incision will become the new superior helical rim. The anterior skin and cartilage flap is elevated from the posterior auricular skin and rotated superiorly to replace the missing superior pinna. The flap lifts easily along the natural plane between the perichondrium and the skin of the posterior auricle. The conchal bowl donor-site defect is repaired with a skin graft. If the postauricular skin is intact, a postauricular island pedicle flap can also be considered to repair the conchal bowl donor-site defect. If there is additional exposed cartilage along the helical rim and scaphoid fossa, the remaining defect can be repaired with a postauricular interpolation flap (PIF) (Fig. 41-23).



A



B



C



D

Figure 41-22. (A) Full-thickness helical rim defect with composite flap design based off helical root. (B) Skin and cartilage transposition flap elevated. (C) Composite flap transposed to reach upper helical rim with intact skin pedicle based at helical root. (D) Three months postoperatively.



Figure 41-23. (A) Full-thickness helical rim defect with exposed antihelical cartilage. (B) Skin and cartilage transposition flap elevated with pedicle based at helical root. (C) Skin and cartilage transposition flap transferred. (D) Postoperative appearance with postauricular flap covering antihelical defect. (E) Two months postoperatively after postauricular interpolation flap separated.

Bilobed flaps

Bilobed flaps have been described for postauricular and helical rim reconstruction.^{32,33} They can be conceptualized as transposition flaps with a significant rotational component, and as such may be useful when recruiting skin from the postauricular sulcus for helical rim defects.

Interpolation flaps

Staged pedicled flaps may be necessary to recruit ample tissue for large auricular defects.

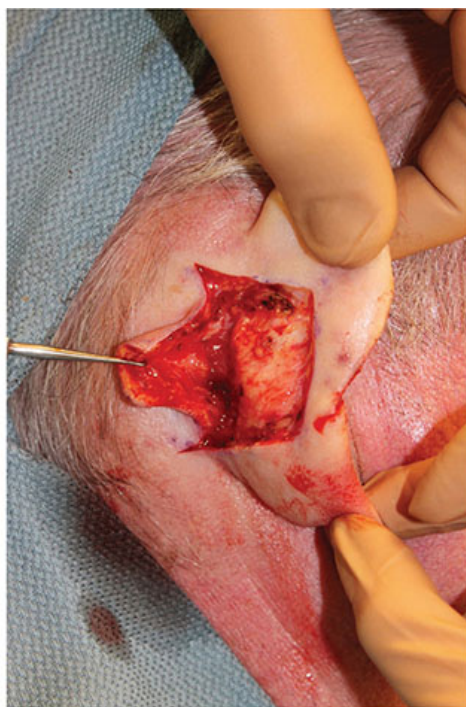
Postauricular interpolation flap

The PIF is an ideal reconstructive option for ear defects that are too large for local flaps or need more structural support or volume than skin grafts. The PIF is ideally for tall defects or composite defects near the free margin of the pinna. The PIF may be combined with free cartilage grafts to add contour and support.

A template of the defect is transferred to the skin of the postauricular sulcus and mastoid. The position of the template is modified, depending on the size and characteristics of the primary defect. For defects isolated to the helical rim, the leading edge of the flap can be drawn directly within the postauricular sulcus. As the template is drawn toward the mastoid skin, these horizontal lines may be widened slightly and Burow's advancement triangles may be added to facilitate additional flap movement. For defects that extend on the antihelix, the PIF will gain additional length by locating the leading edge of the flap on the postauricular skin (Fig. 41-24). An isthmus of posterior auricular skin between the leading edge of the flap and the proximal defect is left to prevent scarring between the raw surfaces of the posterior auricular cartilage and mastoid. Ideally, the base of the PIF will not include hair that could be transferred to the ear.



A



B



C



D

Figure 41-24. (A) Broad anterior auricular defect. (B) Postauricular interpolation flap incised and elevated above perichondrium. (C) Postauricular interpolation flap inset. (D) Two months postoperatively after postauricular interpolation flap separated.

Cartilage grafts should be considered if the structural integrity of the ear or convex silhouette of the helical rim has been compromised. Conchal bowl cartilage of the contralateral ear can be used as a C-shaped strut under the PIF for larger, full-thickness helical rim defects (Fig. 41-25). The graft may be sutured to the edges of the defect before transferring the PIF.

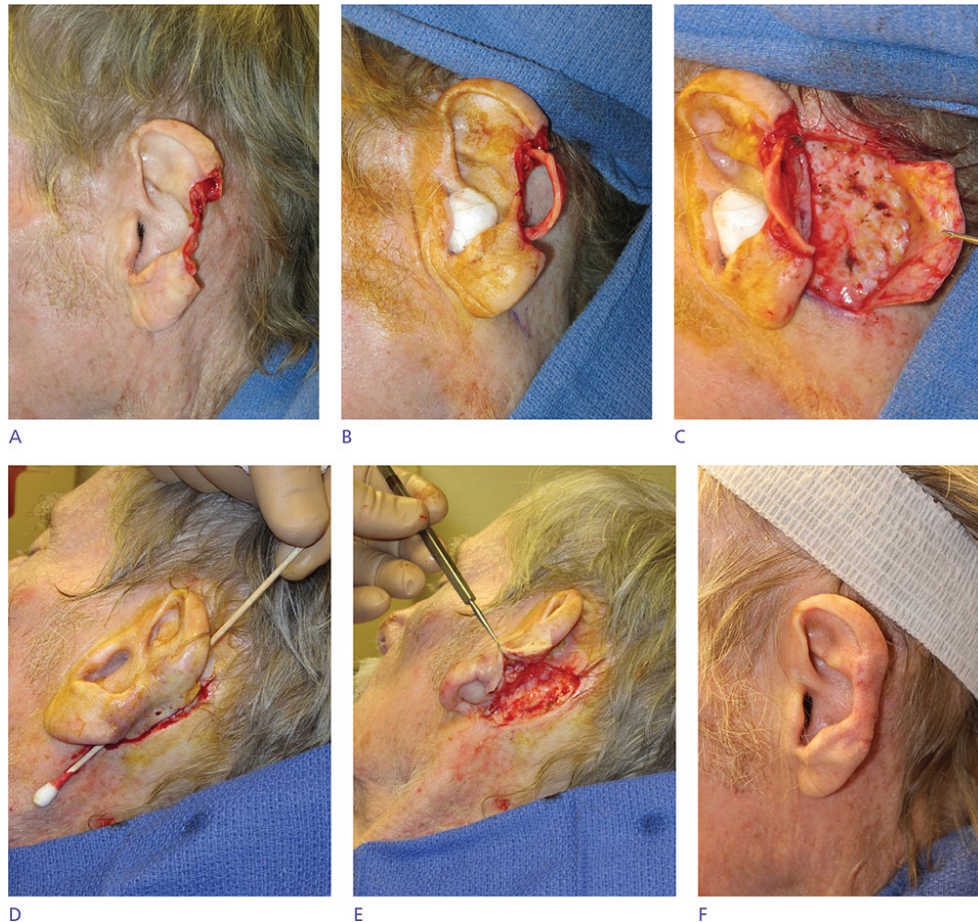


Figure 41-25. (A) Full-thickness helical rim defect. (B) Cartilage graft inset for volume and stabilization. (C) Postauricular interpolation flap elevated above mastoid fascia. (D/E) Postauricular interpolation flap division. (F) Three months postoperatively after postauricular interpolation flap separated.

The anterior and lateral edges of the PIF are incised to the perichondrium (if the leading edge of the flap is designed on the postauricular surface) and mastoid fascia. The flap is elevated at the level of the perichondrium to the posterior sulcus, where it transitions to mastoid fascia. The dissection is carried as far proximally as necessary in order to have the flap comfortably reach the most distal aspect of the surgical defect. If necessary, superior and

inferior Burow's triangles may be removed at the proximal base of the PIF, which can assist flap movement toward the distal aspect of the defect.

Careful hemostasis is necessary, since the donor site will not be accessible once the flap is transferred to the ear. If tension is excessive, the pinna may be pinned to the mastoid with sutures to help the flap reach the defect more easily. The PIF key sutures align the leading edge of the flap to the recipient area. Buried vertical mattress sutures at the helical rim attachments evert tissue to maintain the natural convexity. If the PIF extends over the scaphoid fossa, quilting sutures may be used to tack the flap down in this area and attempt to recreate the natural concavity.³⁴

Takedown is performed approximately 2 to 4 weeks after the initial procedure when the flap pedicle is divided at its proximal base near the mastoid hairline. The freshly cut proximal edge of the flap is thinned and shaped, then sutured to the recipient area in a layered fashion. The donor area can be undermined and advanced toward the postauricular sulcus or left to heal by second intention. If both the posterior ear and mastoid are deepithelialized, either closing the donor site or covering one surface with a skin graft will prevent scarring of the ear to the scalp.

Complications of the PIF are rare and can usually be avoided by proper flap design, meticulous hemostasis, and proper postoperative wound care. Postoperative bleeding can be prevented with careful intraoperative hemostasis or gently wrapping the pedicle with a hemostatic dressing, such as Surgicel. In order to prevent infection and chondritis, patients may be placed on a prophylactic course of antibiotics. Nonsteroidal anti-inflammatory medications may assist with minimizing pain and inflammation.

Temporoparietal fascial flap

The temporoparietal fascial flap (TFF) is a thin, pedicled flap useful to reconstruct large auricular defects. Often used for traumatic ear avulsion, the TFF may be used in staged ear reconstruction for vascular coverage of cartilage and cartilage grafts.³⁵ Over 85% of the flap's blood supply is derived from the STA, with the remaining perfusion delivered by the PAA and occipital artery.³⁶

Prior to designing the flap, a history of surgery, trauma, and radiation to scalp/temporozygomatic regions should be excluded.³⁷ A Doppler may be used to trace the path of the STA, which is most easily identified 1 cm

anterior to the tragus. This vessel runs cephalically and then branches into frontal and parietal branches at the uppermost aspect of the pinna (typically 3 cm above the zygomatic arch). The superficial temporal vein and auriculotemporal nerve follow a similar course.

An incision is made over the course of the artery through skin to the base of the subcutaneous fat. The incision must not extend more deeply, since the artery runs on the superficial surface of the superficial temporal fascia. The superior portion of this incision may be designed with a Y-shape to increase fascial exposure. Bald patients and those with shorter hairstyles may find these incisions difficult to camouflage. The flaps are then carefully elevated leaving the temporoparietal fascia intact.

When an adequate surface area of the temporoparietal fascia has been exposed, the path of the temporal branch of the facial nerve should be identified. Elevating the temporoparietal fascia will cause ipsilateral brow paralysis if it extends over the course of the nerve. Pitanguay's line from the tragus to the lateral brow may serve as a surface landmark to avoid nerve injury. The frontal branch of the facial nerve may also be traced from the tragus to a point that is 3 cm superior and 2 cm lateral to the superior orbital rim³⁷. The flap is elevated in the loose areolar plane above the deep temporalis fascia. The flap's pedicle is eventually narrowed to less than 2 cm as it approaches the helical root so that it may be easily mobilized and transferred toward the ear. The flap is sutured over the exposed cartilage, and a skin graft is placed on its outer surface. The donor site is repaired in a layered fashion. Since the TFF is a pliable flap, the pedicle may not be conspicuous. However, a bulky pedicle may be detached 3 to 4 weeks after the initial inset.

CONCLUSIONS

Successful auricular reconstruction begins with preservation of patient hearing by ensuring EAC patency. Restoration of the oval ear silhouette and its relative position to the temporal scalp facilitates optimal cosmesis. Thorough knowledge of periauricular anatomy allows for localization of the facial nerve's main trunk and also maximizes the use of adjacent tissue to reconstruct challenging defects.

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CHAPTER 42 Reconstruction of the Cheeks

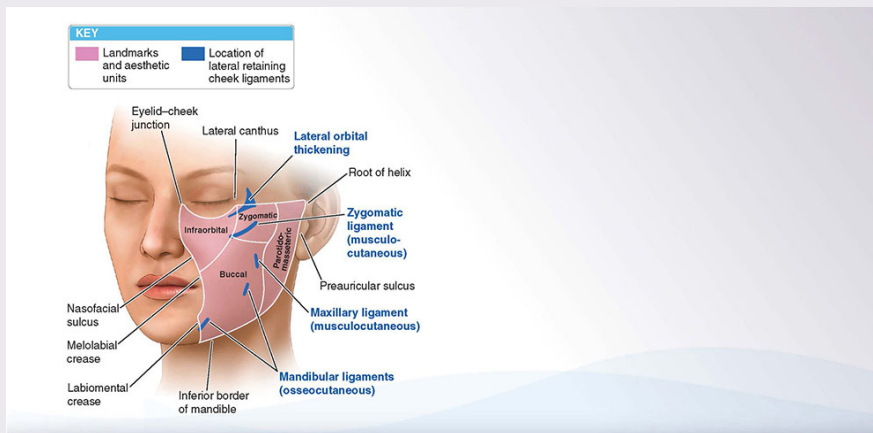
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SUMMARY

- The cheek is the largest subunit of the face, and reconstruction aims to restore its soft contours, avoid distortion of the adjacent eyelid, nose, and mouth, and preserve underlying critical anatomic structures.

- While cheek reconstruction benefits from a robust blood supply and ample tissue reservoir, the presence of free margins around its borders, as well as the parotid gland, duct, and facial nerve branches at its deep aspect, makes an appreciation of the underlying anatomy of vital importance.

Beginner Pearls



- The contours of the cheek reflect the shape of the underlying fat pads. These contours change with age.
- The cheek skin is anchored by osseocutaneous ligaments that affect contour and mobility of skin flaps.
- Primary closure with side-to-side approximation of the edges of a fusiform wound is the most common reconstruction method for cheek defects.

Expert Pearls



- Rotation and advancement flaps are useful for larger cheek defects or those abutting cosmetic subunit boundaries.
- SMAS plication can be very useful when closing larger defects, as it both shifts tension deep and substantially reduces defect size.

Don't Forget!



- Skin grafts are used only infrequently on the cheeks.
- The parotid may appear similar to fat.
- Large defects and those approaching the lower eyelid may benefit from repair with two adjoining flaps or a flap and a graft, rather than a single reconstructive modality.

Pitfalls and Cautions



- The potential for cheek closures to push skin against free margins, such as the lower eyelid, should always be considered.
- While V-Y island pedicle flaps are used frequently on the cheeks, meticulous suturing is critical in order to minimize the unsightly appearance of a triangular shaped scar that does not conform to cosmetic unit boundaries.

Patient Education Points



- Always gauge a patient's willingness to undergo and recover from an extensive procedure *before* it is initiated.
- Some patients may prefer a small partial closure or healing by secondary intention to a more involved and much larger flap.

Billing Pearls



- Random pattern single stage flaps on the cheeks are coded with 14040 or 14041, and these codes include the excisional component; it is not appropriate to bill both an excision and a flap repair code simultaneously, except for Mohs excision codes.
- When coding a flap, graft, or linear repair, medical necessity is the ultimate arbiter of appropriateness.

CHAPTER 42 Reconstruction of the Cheeks

INTRODUCTION

The cheek is the largest subunit of the face, and reconstruction aims to restore its soft contours, avoid distortion of the adjacent eyelid, nose, and mouth, and preserve underlying critical anatomic structures.

While cheek reconstruction benefits from a robust blood supply and ample tissue reservoir, the presence of free margins around its borders, as well as the parotid gland, duct, and facial nerve branches at its deep aspect, makes an appreciation of the underlying anatomy of vital importance.

ANATOMY

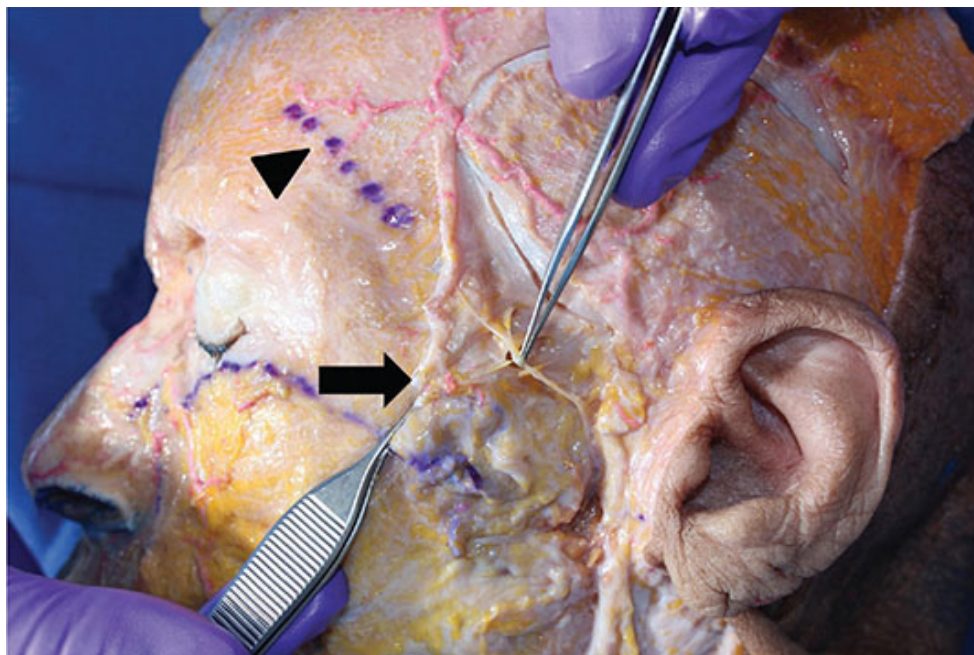
Medially, the cheek joins the nose at the nasofacial sulcus, the lips at the melolabial fold, and the chin at marionette lines. Inferiorly, the cheek extends to the mandible. Laterally, it extends to the ear. Superiorly, the orbital rim and the zygomatic arch delineate the cheek from the eyelid and temple. This section will focus on key anatomic principles to consider for cheek reconstruction.

The cheek covers and protects the facial nerve branches and parotid duct

The skin of the cheek covers and protects the branches of the facial nerve and the parotid duct. The parotid gland lies over the masseter muscle, and its

parenchyma adds extra protection to the facial nerve on the posterior one-third of the cheek. The branches of the facial nerve and parotid duct are most vulnerable after they emerge from the parotid gland and course through the anterior cheek. The superficial musculoaponeurotic system (SMAS), which is continuous with the platysma inferiorly and the superficial temporal fascia superiorly, protects all of the branches of the facial nerve and parotid duct.¹

Topographic landmarks help map the paths of the facial nerve branches that course through the cheek.² The frontal branch follows a line from 0.5 cm below the tragus to 1.5 cm above the lateral brow (Fig. 42-1). Its rami cross over the periosteum of the zygomatic arch before traversing the temple on their way to innervate the frontalis, orbicularis oculi, corrugator supercilii and anterior and superior auricular muscles. The zygomatic and buccal branches have numerous communications as they cross the anterior two-thirds of the cheek to innervate the lip elevators and nasal muscles. The midway point on a line drawn from the root of the helix to the lateral commissure of the mouth identifies the path of the branch that innervates the zygomaticus major muscle.³ The marginal mandibular nerve courses along the inferior border of the mandible and crosses immediately superficial to the facial artery at the anterior border of the masseter muscle before supplying the lip depressor muscles (Fig. 42-2).



A

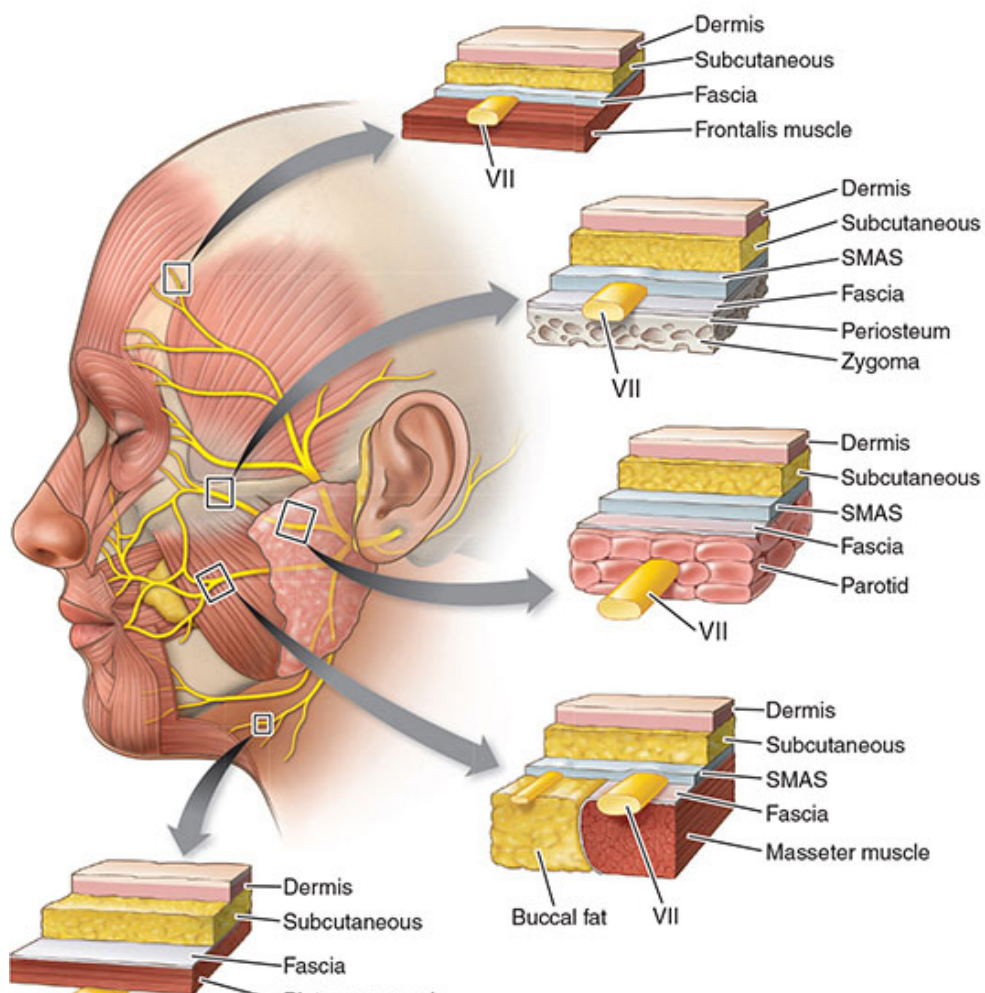




Figure 42-1. Temporal nerve anatomy. (A) The course of the temporal branch was mapped topographically from 0.5 cm below the tragus to 1.5 cm superior to the lateral brow (*arrowhead* indicates anticipated path of the nerve). The superficial musculoaponeurotic system has been incised and retracted (*black arrow*), revealing the main ramus of the temporal branch of the facial nerve. (B) Differential depth of the facial nerve.

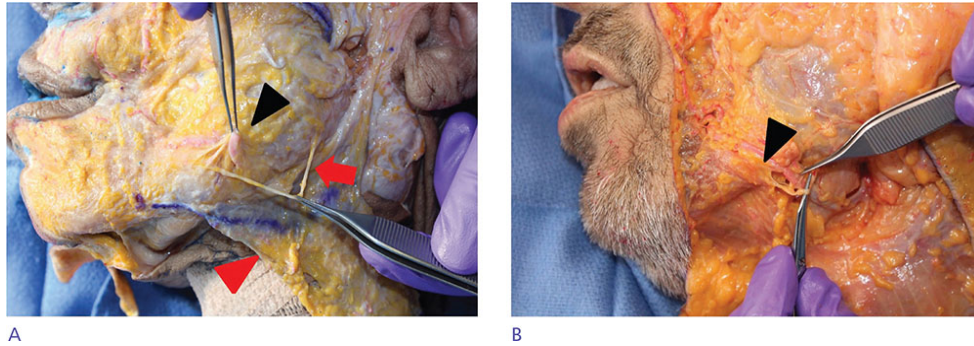


Figure 42-2. Marginal mandibular branch of facial nerve. (A) The SMAS has been retracted (*red arrowhead*) and the marginal mandibular nerve (*red arrow*) has been dissected as it courses from the tail of the parotid gland along the mandible to the lip depressor muscles. Note that the nerve passes superficial to the facial artery (*black arrowhead*). (B) Another cadaver dissection demonstrating innervation of the depressor anguli oris by the marginal mandibular nerve (*black arrowhead*).

The parotid duct emerges from the anterior border of the parotid gland approximately 1 cm inferior to the zygomatic arch. It runs in an anterior direction superficial to the masseter muscle and deep to the buccal branch of the facial nerve (Fig. 42-3).⁴ The transverse facial artery accompanies the duct. At the anterior border of the masseter muscle, the duct dives medially, pierces the buccinator muscle, and drains saliva into the oral cavity at the parotid papilla opposite the second upper molar.

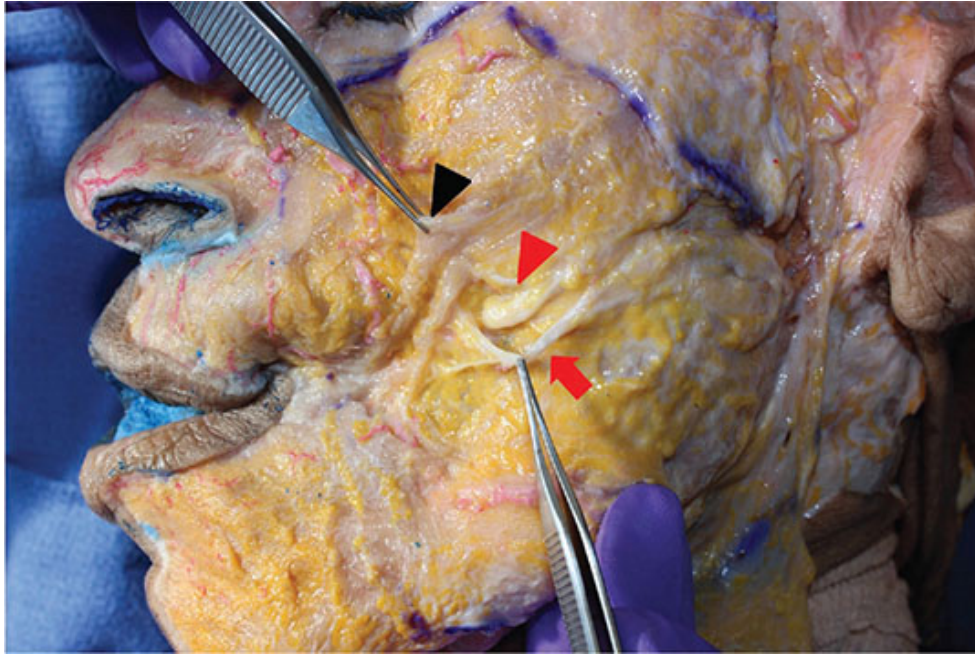


Figure 42-3. Anatomy of the parotid duct. The SMAS has been incised and elevated (*black arrowhead*). The buccal branch of the facial nerve (*red arrow*) courses parallel and superficial to the parotid duct (*red arrowhead*), which is seen here as it dives medially at the anterior border of the masseter muscle to pierce the buccinator muscle and empty into the mouth.

The contours of the cheek reflect the shape of the underlying fat pads. These contours change with age

A thin layer of tightly organized fat is firmly attached to the dermis of the cheek skin. For most local reconstructions of the cheek, the undermining plane lies immediately deep to this subdermal layer of fat and above the superficial fat compartments. Compared to the compact subdermal fat, the underlying superficial fat compartments have grossly larger and more loosely organized fat lobules (Fig. 42-4). Fibrous septae divide the superficial fat into distinct anatomic zones, including the nasolabial, medial, middle, lateral, and jowl compartments.^{5,6} These fibrous septae correspond to the location of some of the retaining ligaments of the face (Fig. 42-4C).⁷ The deep fat compartments, including the medial, lateral, and buccal fat, comprise a third layer that buttresses the superficial fat and adds to cheek projection.^{5,8}

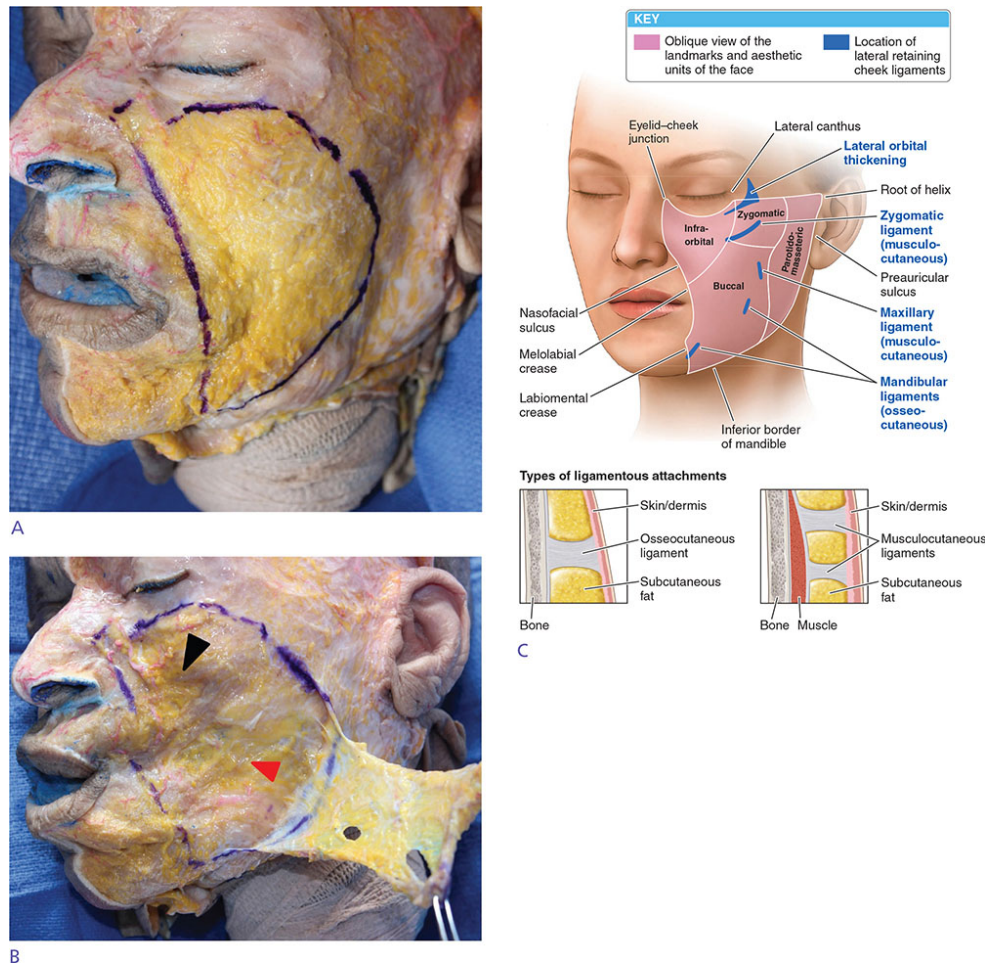


Figure 42-4. Anatomy of fat pads of the cheek. (A) The skin and the subdermal layer of fat have been removed, revealing the underlying superficial fat pads (*outlined in purple ink*). These fat lobules are larger and disorganized, relative to the smaller, tightly organized subdermal fat. (B) The superficial fat pads have been retracted revealing the deep medial (*black arrowhead*) and buccal fat pads (*red arrowhead*). Note that the retracted superficial fat pads are contiguous with the SMAS of the platysma and superficial temporal fascia. (C) The retaining ligaments of the cheek.

These superficial and deep fat compartments alter the volume and projection of the cheek during the aging process. The angular or inverted triangular appearance of the youthful face results from the juxtaposition of the concave buccal cheek and the convex, fat-filled malar and lateral cheek.⁹ Descent of the superficial fat pads of the cheek contributes to the square configuration of the aged face.⁹ The fat pads are also important during reconstruction. Undermining that includes the deeper layers of fat may impart a bulky appearance, and mobility may improve when the flap pedicle is centered over the relatively pliable fat compartments.

The cheek skin is anchored by osseocutaneous ligaments that affect contour and mobility of skin flaps

The dermis of the cheek skin is anchored to the underlying bones, muscles, or parotid fascia by ligaments that support the normal position of facial soft tissue. These ligaments are routinely encountered as areas of resistance that require sharp undermining to elevate and mobilize flaps, and some of them correspond to the fibrous septae that separate the superficial fat compartments.^{6,7} These ligaments also serve as tacking points to drape skin flaps with good contour and to minimize tension of the dermal sutures at the flap edges.

The variable names and descriptions of these ligaments may be confusing.^{7,9-11} Two ligaments connect the cheek to bone. The zygomatic ligament anchors the skin of the cheek to the anteroinferior border of the zygomatic arch behind the insertion of the zygomaticus minor muscle.¹⁰ A sensory nerve, motor branch of the zygomatic nerve, and a branch of the transverse facial artery lie in close proximity to the zygomatic ligaments.^{9,10} This ligament is commonly encountered as the major restriction to motion of a cervicofacial advancement flap, and is a useful tacking point to decrease tension on the lower eyelid during reconstructive surgery (Fig. 42-5). The second osteocutaneous ligament is the mandibular ligament, which tethers the cheek skin to the anterior third of the mandibular body approximately 1 cm superior to the mandibular border. The loose skin of the jowl hangs over this firm attachment, which is a useful tacking point to decrease tension on the lower lip. The marginal mandibular nerve runs close to the mandibular ligament.^{7,12}

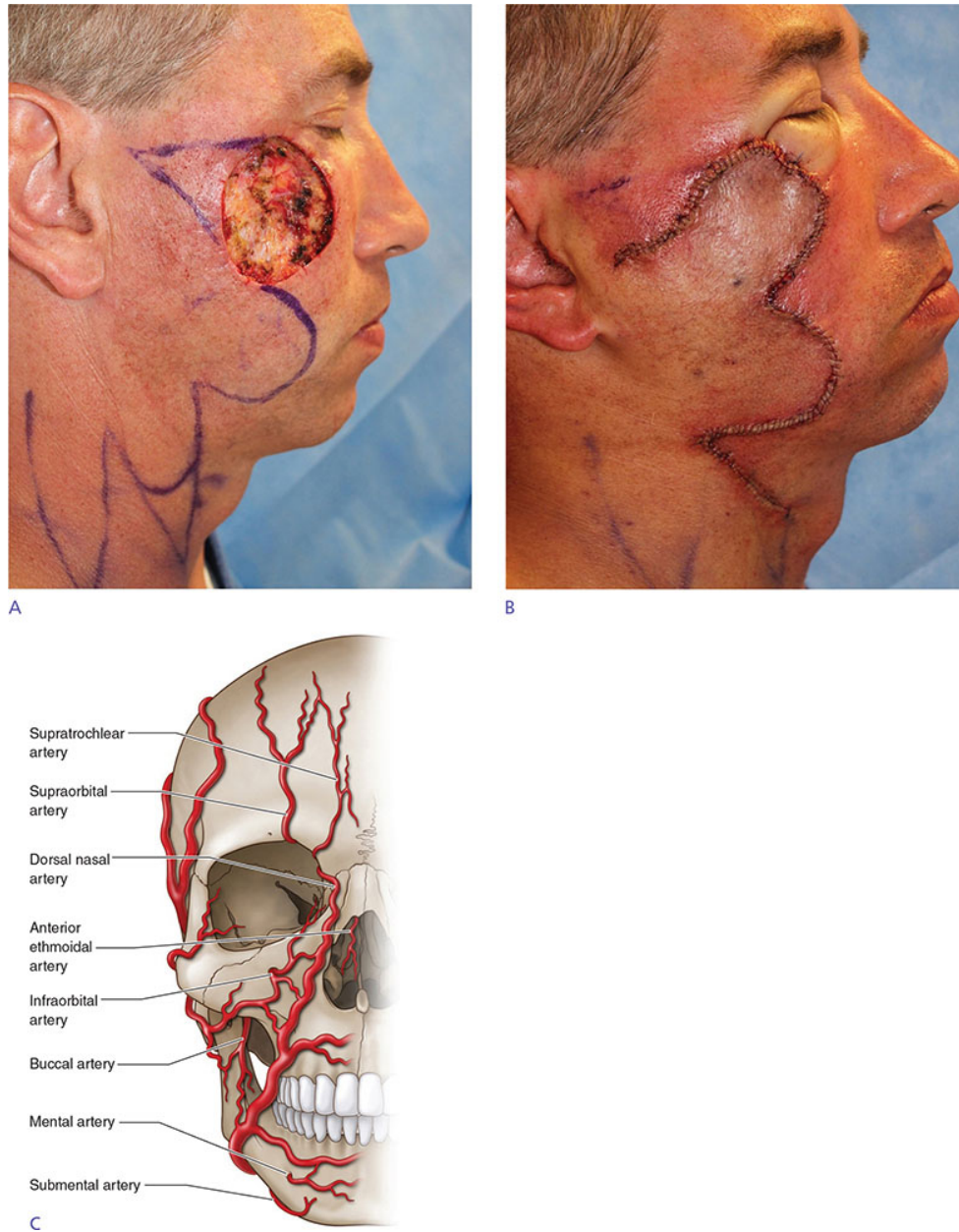


Figure 42-5. Cheek retaining ligaments are good targets for tacking sutures during reconstructive surgery. (A) A bilobed flap is designed to repair a Mohs defect over the zygoma. (B) The undersurface of the dermis of the primary lobe has been tacked to the zygomatic ligament to eliminate tension of the dermal sutures at the distal end of the flap near the eyelid. (C) Vascular anatomy of the cheek.

The remaining ligaments firmly connect the cheek skin to the underlying muscle or fascia. Dense connective tissue joins the posterior border of the platysma and the parotid fascia to the dermis of the skin of the anteroinferior auricular area. Branches of the great auricular nerve course closely to this

ligament, which is often termed the platysma-auricular ligament¹⁰ or the preauricular parotid cutaneous ligament.⁹ The subdermal fat is scant in this region and sharp dissection is necessary to elevate the skin inferior to the ear. The parotidomasseteric cutaneous ligament connects the skin with the parotidomasseteric fascia and marks the course of the zygomatic branch of the facial nerve. The anterior platysma-cutaneous ligament consists of condensed connective tissue linking the platysma or parotid fascia to the dermis in the mid cheek.^{9,10}

The cheek has a robust blood supply

Two branches of the external carotid artery, the superficial temporal artery and the facial artery, provide the major blood supply to the cheek. Planning of cheek reconstruction requires knowledge of the course of these arteries and their perforators (Fig. 42-5C).

The superficial temporal artery is a terminal branch of the external carotid artery and the primary blood supply to the posterior cheek. It begins in the substance of the parotid gland before piercing the SMAS between the temporomandibular joint and the tragus. It then runs superiorly over the zygomatic arch and divides into frontal and parietal branches that supply the temple, forehead, and scalp. The superficial temporal artery gives off the transverse facial artery, which initially runs through the parotid gland and courses anteriorly over the masseteric fascia close to the parotid duct and anastomoses with the facial artery.¹³ More distally, the superficial temporal artery or its frontal branch gives off the zygomatico-orbital artery, which runs toward the face parallel to the zygomatic arch.¹³ The superficial temporal artery has at least two perforating vessels, one at the level of the tragus and the other within 1-cm cephalad, which can be used to form a thin pedicle on flaps used to repair cheek defects.^{14,15}

The facial artery branches off the external carotid artery and is the main blood supply for the anterior cheek.¹⁶ It crosses the angle of the mandible at the anterior edge of the masseter muscle deep to the platysma muscle. It courses toward the oral commissure deep to the risorius muscle and superficial to the buccinator muscle.^{17,18} The facial artery runs an average of approximately 15 mm (range: 9–20 mm) lateral to the oral commissure

within the musculature under the nasolabial fold.^{17–20} The facial artery issues several named branches, including the premasseteric artery, labiomentental artery, inferior and superior labial arteries, the inferior alar artery, the lateral nasal artery, and the angular artery.²¹ Although the anatomy of the angular artery varies among individuals, it most commonly originates from the facial artery at the branching point of the lateral nasal artery adjacent to the nasal ala and runs in the nasofacial sulcus until it anastomoses with the dorsal nasal artery from the internal carotid system in the medial canthus.²² An average of six perforating vessels from the facial artery pierce the overlying SMAS to supply the skin (Fig. 42-6).²³ Most of these perforating vessels are located in the nasolabial fold, which consequently serves as an excellent donor site for perioral and perinasal reconstruction.²³

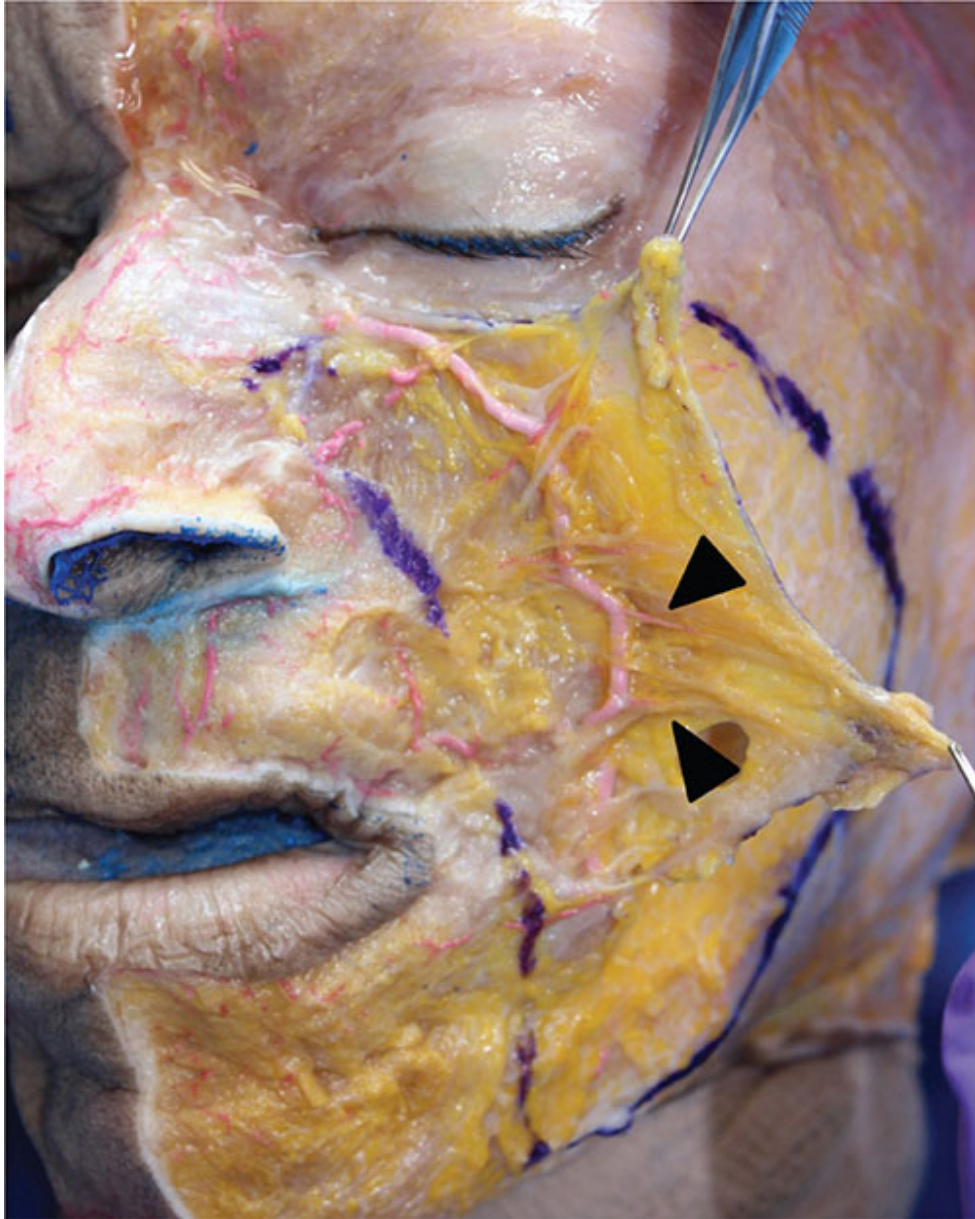


Figure 42-6. An average of six perforating vessels from the facial artery pierce the overlying SMAS (retracted with forceps). The *black arrowheads* indicate two of the perforating vessels.

PRINCIPLES OF RECONSTRUCTIVE DESIGN

In descending order of importance, principles of aesthetic surgical design include preserving and restoring free margins and contour, placing scars in cosmetic subunit junction lines, and placing scars along relaxed skin tension lines. The cheek is adjacent to the free margins of the central face, so tension

and scar contraction can affect the position of the eyelids, nasal alae, and lips. The underlying fat pads give the cheek soft, subtle contours. Volume excesses and deficiencies noticeably interrupt cheek contour. The junction of the cheek with the cosmetic subunits of the mouth, nose, preseptal eyelid, and ear are effective locations to camouflage scars. Relaxed skin tension lines are prominent in the middle of the cheek subunit, and scars that fall within these rhytides are better disguised and undergo less tension (Fig. 42-7).

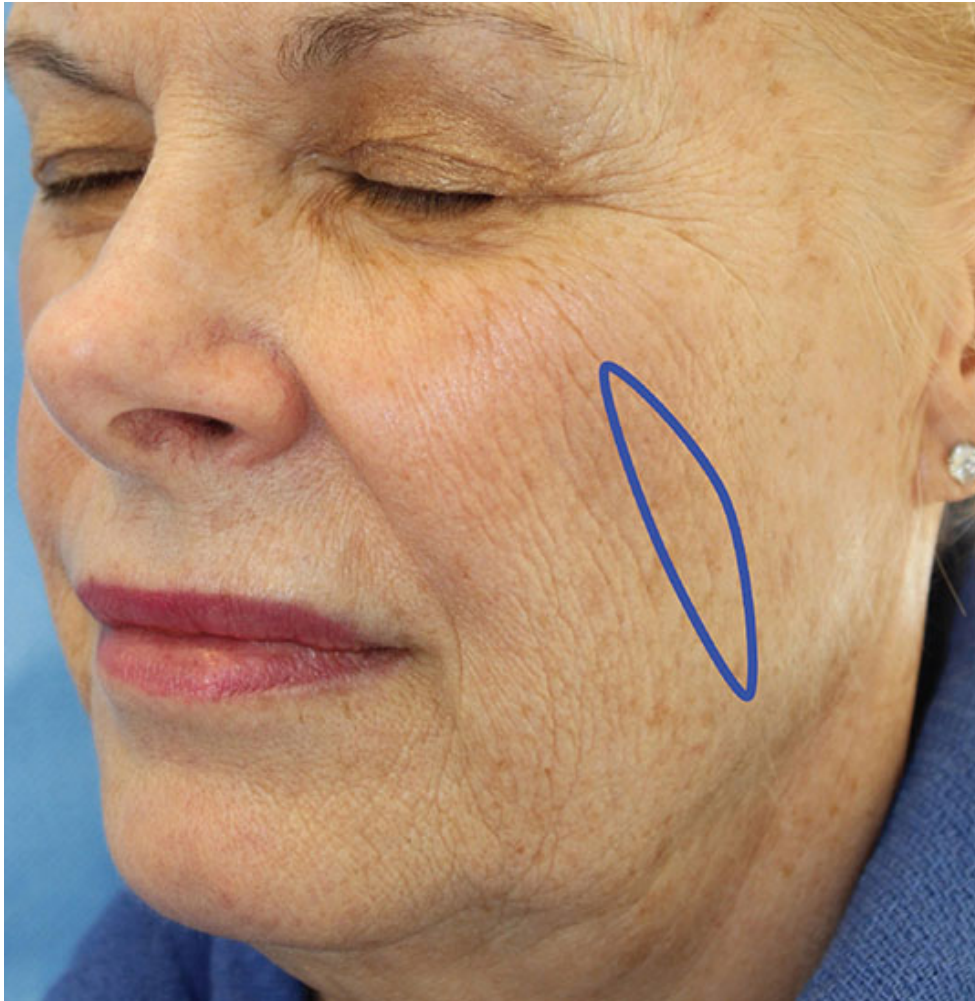


Figure 42-7. The tangential relaxed skin tension lines are prominent on the anterior aspect of this photodamaged cheek. A fusiform excision oriented parallel to the relaxed skin tension lines has less tension and less conspicuous scarring.

For simplicity, the cheek may be divided into three zones. Zone 1 refers to the anterosuperior cheek in the premaxillary area inferior to the lower preseptal eyelid. Zone 2 describes the posterolateral cheek in the

preauricular and buccal areas. Zone 3 refers to the anteroinferior cheek at the nasolabial fold and jowl.

Second intention healing

Second intention healing is uncommonly used to manage cheek wounds, because reconstruction with linear closures, flaps, or skin grafts is usually possible and provides a superior aesthetic and functional result. Scars from second intention healing predictably contract and heal with a shiny texture, which often contrasts sharply with the cheek skin, particularly in bearded areas. Scar contracture near free margins can distort the position of the lower eyelid and lips. Second intention healing on the cheek is most likely be employed in the preauricular region of zone 2, where the scar is not visible on frontal view and where scar contraction does not interrupt the contours of the midface or the position of adjacent free margins (Fig. 42-8).



Figure 42-8. (A) The patient declined flap or graft reconstruction in favor of second intention healing. (B) The scar has predictably healed with a shiny texture and a ridge along the preferred line of tension. The wound was far enough from the central face that scar contraction did not alter free margin position.

Contracted scars from second intention healing usually form a long axis along the relaxed skin tension lines of the cheek. Patients should expect evolving color and volume of the scar. Scars that are initially pink and hypertrophic usually mature to a hypo- or hyperpigmented scars with flatter contour.

Primary closure

Primary closure with side-to-side approximation of the edges of a fusiform wound is the most common reconstruction method for cheek defects.²⁴

Tension lies along a single vector running perpendicular to the long axis of the fusiform design, and is greatest at the center and decreases toward the apices. Linear closures are usually oriented parallel to the relaxed skin tension lines, which the patient can accentuate with a forceful smile. To avoid standing cones and to maintain normal contour, the ideal angles at the apices of a fusiform excision are <30 degrees, which requires a length:width ratio of at least 3:1. The ideal orientation of fusiform closures on the cheek depends on wound location.

Fusiform closures of zone 1 wounds are usually oriented with the long axis perpendicular to the lower eyelid (Fig. 42-9). The horizontal tension vector from this design prevents lower lid ectropion. Elongation of the central axis after wound closure may temporarily push up on the lower eyelid, which usually returns to normal position within a couple of weeks. An M-plasty may be used to keep the superior standing cone from encroaching on the lower eyelid margin. For infraorbital cheek defects that have a longer horizontal diameter, an S-plasty may be used to keep tension vectors parallel to the free eyelid margin (Fig. 42-10).

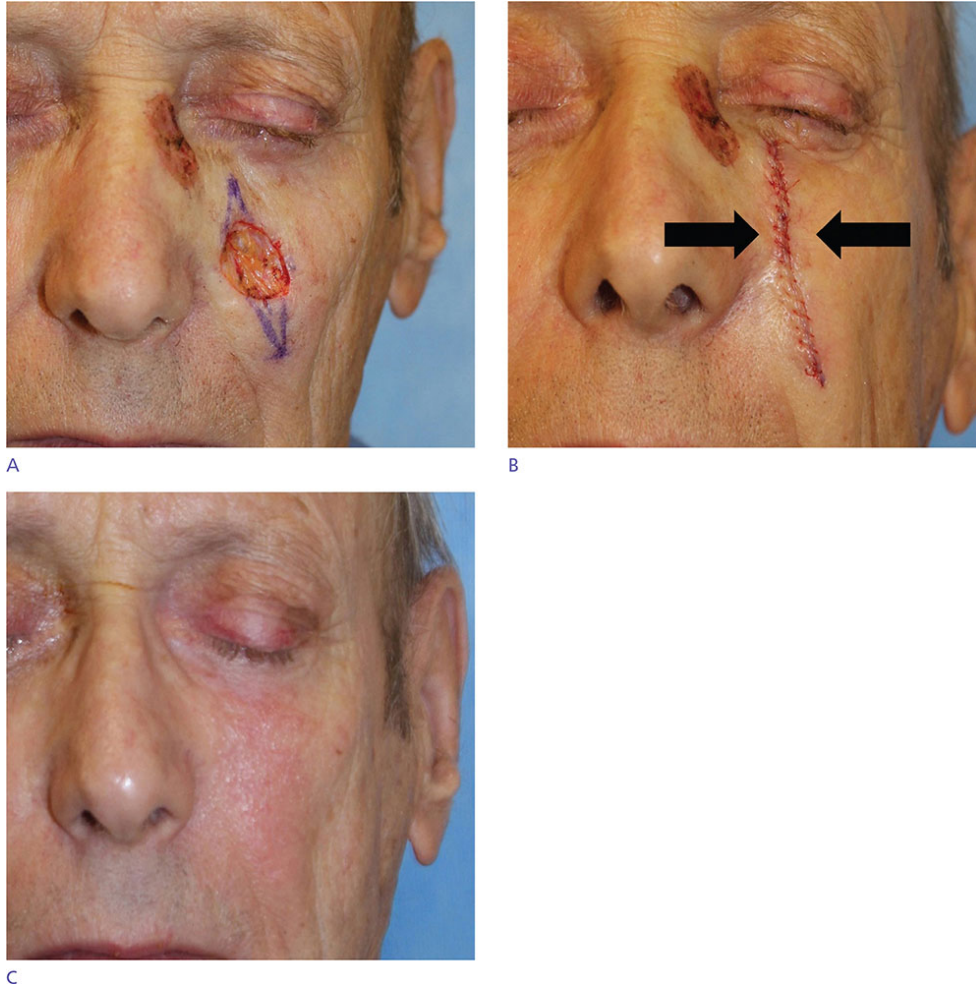


Figure 42-9. (A) A primary closure with a long axis perpendicular to the eyelid is designed for this zone 1 cheek defect. (B) The horizontal tension vector (*black arrows*) avoids ectropion. (C) Eyelid position is preserved and the scar is minimally apparent at follow-up.

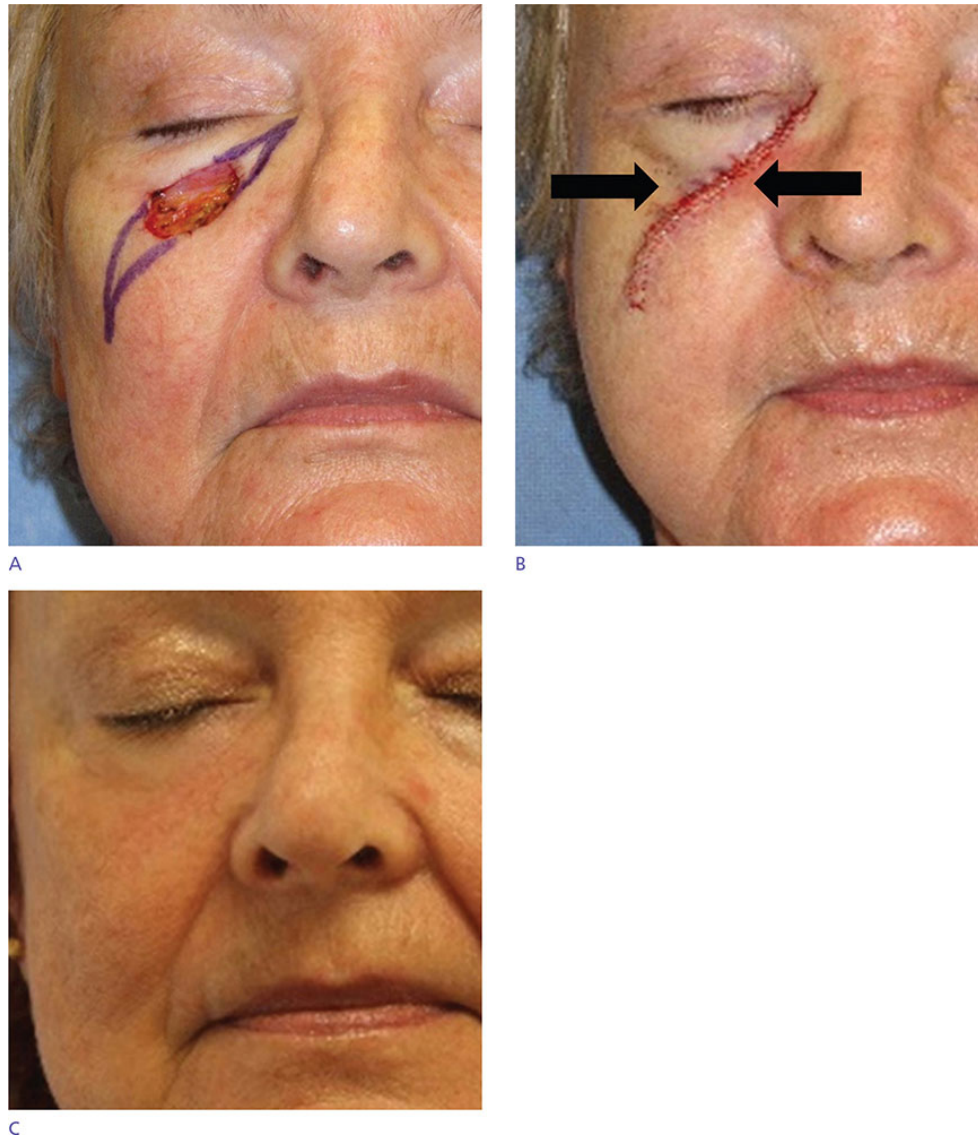


Figure 42-10. (A) An S-plasty is designed for this infraorbital cheek defect with a long horizontal axis. (B) The horizontal tension vectors of the S-plasty avoid ectropion. (C) Eyelid position is preserved and the scar is minimally apparent at follow-up.

Linear closures in zone 3 are generally designed with the long axis parallel to the nasolabial fold and parallel to the relaxed skin tension lines (Fig. 42-11). Fusiform closures predictably flatten the nasolabial fold and can pull on the free margin of the lips and oral commissure. The wound can bow with central depression and relative elevation toward to apices. If the asymmetry from the flattened nasolabial fold or bowed scar is noticeable or if the free margin distortion is greater than can be expected to resolve over time, a local transposition flap may be preferred (Fig. 42-12). A crescentic

design with the longer posterior curve is a variation of the fusiform excision that may be used to create a curvilinear scar mimicking the relaxed skin tension lines (Fig. 42-13).



Figure 42-11. (A) A fusiform excision parallel to the nasolabial fold is designed for this zone 3 cheek lesion. (B) The sutured wound falls within relaxed skin tension lines. (C) The scar is minimally apparent and the nasolabial fold has retained volume at follow-up.

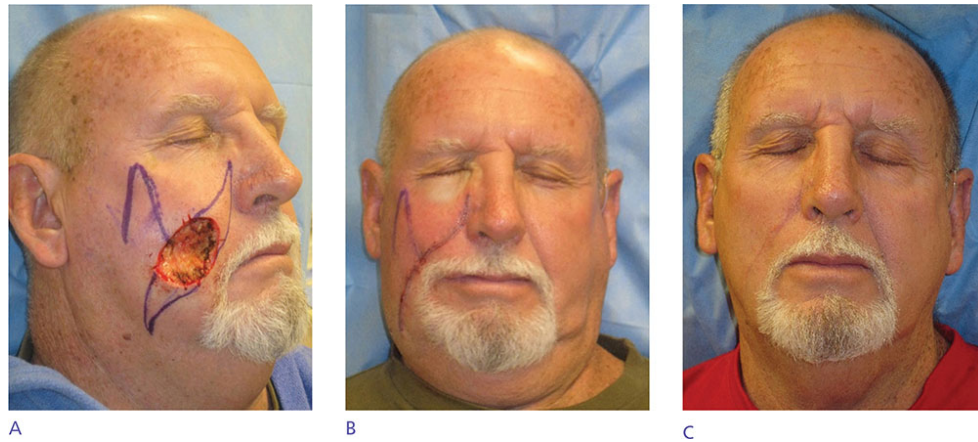


Figure 42-12. Tight zone 3 closures can flatten the nasolabial fold. (A) A rhombic flap and primary closure were considered for this zone 3 defect. (B) The wound was repaired with a primary closure. (C) Flattening of the nasolabial fold from wound tension reveals central facial asymmetry at follow-up.

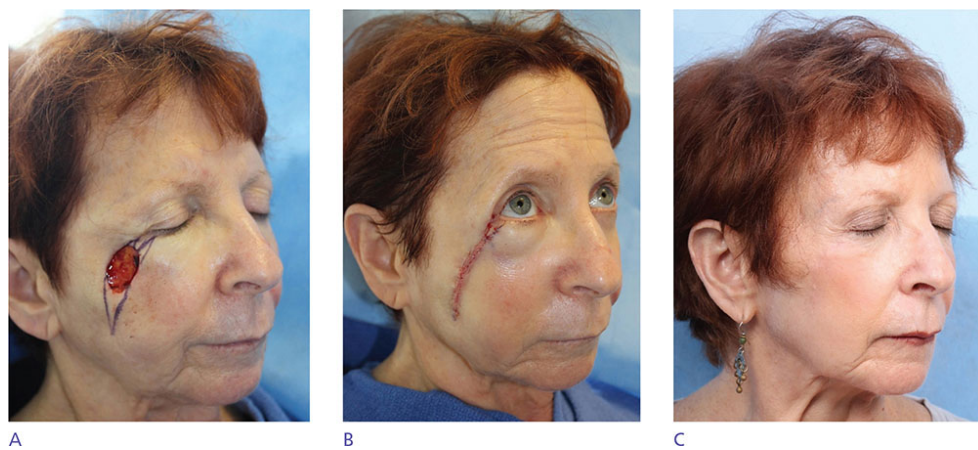


Figure 42-13. Crescentic fusiform excision. (A) A crescentic design was employed to create a curvilinear scar mimicking the relaxed skin tension lines. (B) Sutured wound immediately postoperatively. (C) Imperceptible scar along the relaxed skin tension line at follow-up.

The orientation of linear closures varies between the superior and inferior regions of zone 2. Fusiform closures near the zygomatic arch are often oriented along a tangent continuous with the crow's feet (Fig. 42-14). Wounds closer to the mandible are usually repaired with a vertically oriented axis. Tension increases for wounds closer to the preauricular sulcus, because the auricular cartilage restricts advancement of the posterior wound edge. To avoid excessive tension, advancement or transposition flaps may be

preferred for larger preauricular wounds. For a full discussion of linear closures, see [Chapter 18](#).



Figure 42-14. (A) A tangential fusiform closure is designed to parallel the crow's feet. (B) Eyelid position is preserved despite wound tension. (C) The scar is minimally apparent at follow-up.

Skin grafts

Skin grafts are typically reserved for large, shallow wounds of the cheek. Smaller wounds can usually be repaired with a primary closure or local flap. Deeper wounds are best repaired with flaps that restore volume better than a skin graft.

Large wounds require harvesting grafts from generous tissue reservoirs, which rarely have a good color and texture match for cheek skin. Common reservoirs that allow direct closure of the donor site after harvesting large, full-thickness skin grafts include the periclavicular area, the lower abdomen, or the upper inner arm. Among these options, sun-damaged skin near the clavicle is most likely to resemble cheek skin. The lower abdomen and upper inner arm will almost always be pale compared to the relatively sun-damaged cheek. Split-thickness skin grafts are commonly harvested from the upper thigh or buttock, and they rarely have an ideal color and texture match ([Fig. 42-15](#)).



Figure 42-15. (A) A large defect involving nearly the entire cheek was repaired with a split-thickness skin graft. (B) The graft has healed with a relatively good color match. Scarring may be less conspicuous because the graft margins conform to the cosmetic subunit junction lines of the cheek.

Burow's grafts are one of the best options to obtain acceptable color and texture match for skin grafts of large cheek defects. A standing cone is excised from the inferior aspect of the cheek wound. Direct closure of the standing cone defect shrinks the size of the primary defect to a teardrop shape. A full-thickness skin graft from the standing cone excision is trimmed to match the size of the shrunken defect. The color and texture match are acceptable, since the donor site is immediately adjacent to the primary wounds (Fig. 42-16). For a full discussion of skin grafts, see [Chapter 28](#).



Figure 42-16. Burow's grafts on the cheek often heal with better color and texture match. (A) A Burow's graft is designed to repair this defect. (B) The skin from the inferior standing cone was used

to cover the superior aspect of the wound. (C) The scar has healed with a relatively good color and texture match.

Flaps

Advancement flaps

Advancement flaps rely on a random-pattern blood supply and are useful for wounds that could be closed with a fusiform closure, but one of the standing cones falls in an unfavorable position. An advancement flap maintains tension along the same single vector as a fusiform closure, but it displaces the undesirable standing cone to a more favorable position. In contrast to rotation flaps, advancement flaps do not create secondary defects. Infraorbital wounds in zone 1 and large preauricular wounds in zone 2 are the most common indications for advancement flaps on the cheek.

Zone 1 wounds on the medial infraorbital cheek and nasofacial sulcus often require advancement flaps to deviate the superior standing cone away from the lower eyelid margin (Fig. 42-17). A standing cone is excised from the inferior aspect of the wound. A horizontal incision is made from the superior aspect of the wound laterally toward the temple, and the superior standing cone is shifted laterally toward the crow's feet or sutured out using the rule of halves. Ideally, the horizontal incision is concealed in the cosmetic subunit junction line between the cheek and lower preseptal eyelid. If the superior aspect of the wound does not abut this boundary, the primary defect may be extended superiorly to avoid creating a noticeable horizontal scar in the middle of the cheek subunit. The flap is undermined and advanced from lateral to medial. The zygomatic ligament may restrict medial advancement, and an unanticipated secondary defect can result along the orbital rim if the flap is stretched too aggressively. For this reason, a pure advancement flap is indicated only for small defects. To avoid ectropion from a secondary defect along the orbital rim, it may be necessary to convert to a rotation flap by extending the lateral incision in an arc to the temple and preauricular area.



Figure 42-17. (A) Both a primary closure and advancement flap were considered with this infraorbital cheek defect. (B) An advancement flap was performed to avoid encroachment of the superior standing cone on the lower eyelid. (C) The patient has a minimally apparent scar and preserved eyelid position at follow-up.

Vertically oriented fusiform closure of larger wounds in the preauricular area of zone 3 is frequently not possible because of excessive tension. If a horizontally oriented fusiform excision would be possible, but the auricular cartilage obstructs the posterior standing cone, an advancement flap that slides skin superiorly from the lower cheek and neck may be designed (Fig. 42-18). A horizontally or tangentially oriented standing cone is excised from the anterior aspect of the primary defect. A vertical incision is made from the lateral wound toward the neck, and the posterior standing cone is displaced inferiorly to tuck under the earlobe. Ideally, the vertical incision is camouflaged in the preauricular crease. If the posterior aspect of the wound does not abut this boundary, the primary defect may be extended posteriorly to avoid making a noticeable vertical scar in the middle of the cheek subunit. The flap is undermined and advanced from inferior to superior. For a full discussion of advancement flaps, see [Chapter 21](#).



Figure 42-18. (A) Rhombic and advancement flaps were considered for this preauricular cheek defect. (B) An advancement flap was performed. An incision was made along the preauricular crease, and the posterior standing cone was displaced behind the earlobe. (C) The scar is minimally apparent at follow-up.

Rotation flaps

Rotation flaps have a random pattern blood supply and distribute tension across multiple vectors to minimize distortion at the primary defect. The hallmark of a rotation flap is the arciform incision used to mobilize the surrounding skin. Rotating the flap into the primary defect creates a secondary defect along the arciform incision. A greater arc of flap rotation increases the size of the secondary defect. Tension is distributed along multiple vectors at both the primary and secondary defects.

The cervicofacial rotation flap is used to close larger defects in zone 1 of the anterior cheek (Fig. 42-19). A standing cone is excised along the inferior border to the defect. An arciform incision is made from the lateral defect toward the temple. It is important to extend the incision superior to the lateral canthal angle, as the increased height of the flap will help prevent a secondary defect along the lower preseptal eyelid margin. Depending on the size of the wound or tension on the flap, the arciform incision may be extended posteriorly along the sideburn, preauricular crease, and neck. Smaller, lower tension wounds usually do not require such a large arc to the flap.



A



B



C



D

Figure 42-19. (A) Rotation flap is designed for a defect of the medial zygoma. Note that the incision line was extended superior to the lateral canthal angle to prevent a secondary defect along the lower preseptal eyelid margin. (B) Intraoperative photo demonstrating the arciform incision and extent of undermining. (C) Appearance immediately after surgery. Note removal of the standing cone along the outer edge of the arc (*black arrowhead*). (D) The scar is minimally apparent at follow-up.

The flap is elevated. Sharp undermining is necessary to release the zygomatic ligament and mobilize the flap. The flap is rotated medially toward the defect. Care is taken to keep the main tension vectors parallel to the lower eyelid margin. Despite wide undermining, tension may still be too great for primary closure. A backcut of the flap with or without a z-plasty may facilitate closure (Fig. 42-20).



Figure 42-20. Example of a rotation flap with a backcut and z-plasty to improve mobility.

Even with proper design, a secondary defect at the infraorbital cheek may still threaten ectropion. To close this gap, the flap can slide toward the defect with a combination of rotation and superomedial advancement. If the surgeon anticipates the possibility of superomedial advancement, it is best not to excise the inferior standing cone until the flap is set and the preferred location of the standing cone is obvious. Tacking the undersurface of the flap to the inferior orbital rim is often helpful to transfer tension to the immobile bone and decrease tension of the dermal sutures at the flap edges. Asking the patient to open his or her eyes and mouth and look up is the most effective way to assess the position of the lower eyelid.

After setting the flap in the primary defect, the secondary defect along the arciform incision is closed. In general, the edge of the flap is hiked superiorly toward the temple or superolaterally toward the ear. Tacking the undersurface of the flap to the zygomatic ligament or the lateral orbital rim may be necessary to transfer tension away from the eyelid. If the flap was rotated toward the primary defect along a substantial arc, then direct closure of the secondary defect may not be possible. Second intention healing or skin grafting may be necessary when closure of the secondary defect is not possible.

In patients with a generous reservoir of skin in the nasolabial fold or jowl, it may occasionally be preferable to design an inferiorly based rotation flap ([Fig. 42-21](#)). This design is best suited for zone 1 defects that have their greatest diameter in the horizontal dimension. A standing cone is excised laterally toward the temple. An arciform incision extends from the medial aspect of the primary wound inferiorly along the nasofacial sulcus and nasolabial fold. The flap is elevated and rotated from inferior to superior. The secondary defect along the nasofacial sulcus and nasolabial fold is closed. This flap design must be used cautiously, because the vertically oriented tension vector at the primary defect has a high risk for ectropion, and direct closure of a large secondary defect along the arciform incision can pull the nose laterally. To minimize tension at the eyelid, it is almost always necessary to tack the leading edge of the flap to bone at the infraorbital rim. For a full discussion of rotation flaps, see [Chapter 22](#).



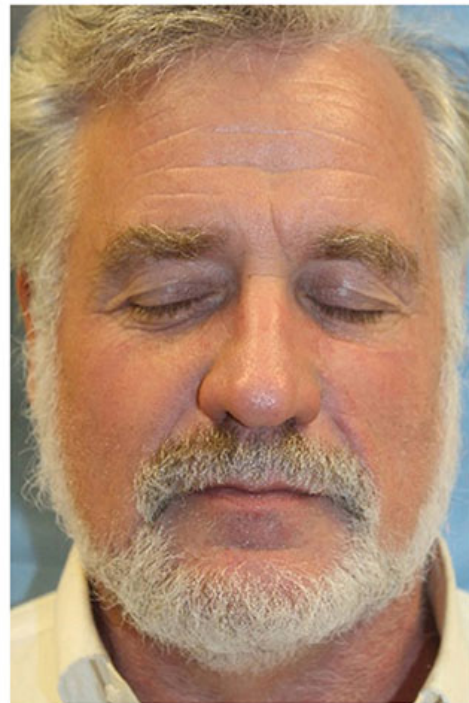
A



B



C



D

Figure 42-21. (A) An inferiorly based rotation flap is designed for this infraorbital cheek defect. (B) Intraoperative photos illustrating the vertical tension vector on the primary defect (*black arrow*). Tacking the leading edge of the flap to the bone at the infraorbital rim decreases tension on the lower eyelid. Note the secondary defect at the nasolabial fold (*black arrowhead*). (C) The position of the

eyelid is undisturbed immediately postoperatively. (D) The scar is minimally apparent at follow-up and eyelid position is intact.

V-Y Island pedicle flaps

V-Y flaps are a common option to reconstruct medium- to large-sized defects of the cheek. They differ from other sliding flaps (e.g., advancement and rotation) in two ways. First, their entire blood supply comes from the flap's undersurface since the dermis is incised around the entire periphery. Second, they are not simply stretched toward the defect, but also pushed toward the primary defect by closure of the secondary defect. Zones 1 and 3 are the most common cheek locations where V-Y flaps are employed. The superficial fat pads beneath the skin in these locations are highly mobile and typically allow the flap to be advanced greater distances than in zone 2.

Traditional V-Y island pedicle flaps are inferiorly based and triangular in design (Fig. 42-22). Flap limbs originate from the medial and lateral caudal borders of the defect and extend inferiorly toward to the mandible. Zone 2 V-Y flaps are most mobile when incisions are carried past the mandible into the jowl and neck area. An angle less than or equal to 30 degrees should be created where the flap limbs meet. Depending upon the size and location of the defect, one or both of the flap limbs may be hidden in a cosmetic junction border such as the melolabial fold or preauricular crease.



Figure 42-22. (A) A traditional V-Y island pedicle advancement flap is designed for this infraorbital cheek defect. (B) The leading edge of the flap has been tacked to the infraorbital rim to avoid downward pull on the eyelid. (C) Eyelid position is intact and much of the scar hides in cosmetic subunit junction lines.

The V-Y flap is circumferentially incised to the level of the SMAS and the peripheral edges are undermined in this plane. The central 30% to 50% of the subcutaneous tissue is preserved, and it is this pedicle upon which the flap “rocks” forward in a superomedial vector. Once careful hemostasis has been achieved, the flap is sutured in place. The risk of ectropion for zone 1 defects can be minimized by tacking the leading edge of the flap to the infraorbital rim.²⁵

The conventional design of the V-Y advancement flap has a number of limitations. First, fascial attachments restrict superior advancement of the flap and may result in undesirable pincushioning. Second, the horizontal scar of the flap’s leading edge is often conspicuous. Finally, traditional V-Y flaps may not stretch to cover tall defects.

Wide undermining of the peripheral skin may help minimize the trapdoor effect of the triangular flap. A crescentic design modification addresses the horizontal scar when employed for defects in the medial portion of zones 1 and 3. Rather than incising the flap at the lateral and medial defect borders, the flap’s leading edges are designed off of the cephalic and caudal defect borders. These limbs then curve around to follow the relaxed skin tension lines of the cheek. As the flap moves superomedially, the leading edge is sutured to align with the cosmetic junction border ([Fig. 42-23](#)). A “pac-man” design modification gains length by rotating the leading edges of the flap to the distal defect ([Fig. 42-24](#)). The final flap scar is fusiform with a line through the center where the two arms meet. If there is concern for vascular compromise, the redundant cone at the flap’s midpoint can be removed at a later date. Frequently, slight tissue protrusions in this location self-resolve. For a full discussion of V-Y island pedicle flaps, see [Chapter 25](#).



Figure 42-23. (A) A crecentic V-Y island pedicle advancement flap has been designed for this medial cheek defect. Note that the lateral arm of the flap originates from the distal (i.e., superior) defect. (B) Appearance immediately postoperatively. (C) Scar at short-term follow-up.



Figure 42-24. (A) A “pac-man” V-Y island pedicle advancement flap has been designed for this defect. Note that the flap limbs originate from the distal defect to gain reach. (B) Appearance immediately postoperatively. Removal of the central standing cone was delayed for several weeks to preserve blood supply. (C) Minimally apparent scar at follow-up.

Transposition flaps

Transposition flaps avoid distortion at the primary defect by displacing key tension to the adjacent tissue reservoirs and by reorienting tension to more favorable vectors. On the cheek, transposition flaps are especially useful for large defects in zones 1 and 3 when tension at the primary defect from a

linear closure or sliding flap would distort the position of the mouth, nose, or eyelid.

As opposed to sliding flaps, which have the greatest tension at the primary defect, transposition flaps displace the greatest tension to the final donor site (i.e., secondary defect of a rhombic flap; tertiary defect of a bilobed flap; and quaternary defect of a trilobed flap). By transferring tension to the donor defects, the transposition flap can be rotated to the primary defect with minimal tension. Transposition flaps for upper cheek defects recruit from the looser skin on the lower half of the cheek; and those for lower cheek defects recruit from the lax skin on the neck.

Rhombic transposition flaps. The rhombic flap is a workhorse flap for many cheek defects. The flap extends from the midline of the defect toward the desired tissue reservoir. For cheek defects, the open limb of the flap usually points to the jawline or neck. The classic rhombic flap has a 60-degree angle at its apex, but lengthening the flap to create a more acute apical angle can facilitate closure and avoid a standing cone deformity at the donor site (Fig. 42-25).



Figure 42-25. (A) A rhombic flap is designed to reconstruct this lower cheek defect. Note that the open limb of the flap points to the tissue reservoir on the neck. Appearance immediately postoperatively (B) and at follow-up (C).

To avoid secondary motion at the primary defect, the flap should have approximately the same surface area as the primary defect and extend perpendicularly from the primary defect. The first key suture closes the secondary defect and bears the greatest amount of tension. The second key suture sets the flap into the primary defect and determines its arc of rotation

as well as the position of the standing cone. As the arc of rotation increases, pivotal restraint effectively shortens the flap, making it more difficult for its distal edge to reach the defect, and the standing cone deformity may encroach on the flap pedicle. It is preferable to set the flap so that the standing cone deformity does not narrow the pedicle. Removing the standing cone is often reserved until the flap has been set in its ideal location.

The triangular shape of the distal flap does not correspond to most circular defects. The surgeon can either trim the flap to match the defect or enlarge the defect to accommodate the flap. Since the distal flap has the most tenuous blood supply, it is usually preferable to trim the excess tissue of the flap to match the defect. For a full discussion of transposition flaps, see [Chapter 23](#).

Bilobed flap. If a rhombic flap is not possible because tension on the skin immediately adjacent to the primary defect is excessive or causes anatomic distortion, the bilobed flap can reach suitable donor sites more remote from the defect ([Fig. 42-26](#)). Compared to the rhombic flap, the geometry and execution of the bilobed flap are more complex.²⁶⁻²⁹



Figure 42-26. (A) A bilobed and trilobed flap was considered and designed for this large medial cheek defect. The trilobed flap design was not necessary. (B) Appearance immediately postoperatively. (C) Scar is inconspicuous at follow-up.

Like the rhombic flap, the bilobed flap also rotates approximately 90 degrees. However, the bilobed flap distributes the rotation between the two lobes, each rotating 45 degrees. The second lobe adds a z-plasty that helps to push the flap toward the primary defect. The tension vector to close the

donor site for the secondary lobe (i.e., the tertiary defect) should not pull on the nearby free margins.

The first key suture closes the tertiary defect and pushes the flap toward the primary defect. The second key suture sets the primary lobe into the defect. The exact position of this suture may vary or require adjustment to create tension vectors that avoid anatomic distortion, to align the standing cone, and to adjust the sizing of the primary lobe. It is often preferable to ensure that closure of the standing cone deformity preserves contour before trimming excess tissue for a precise fit. The secondary lobe will generally have excess length and require trimming to match the secondary defect. For a full discussion of bilobed flaps, see [Chapter 24](#).

Trilobed flap. The trilobed flap has tissue mechanics similar to the bilobed flap with a few distinct advantages ([Fig. 42-27](#)). First, its third lobe allows the flap to reach tissue reservoirs increasingly remote from the primary defect, and it is particularly useful to reconstruct large cheek defects. Second, the third lobe extends the arc of rotation to 120 to 150 degrees and may provide a more favorable tension vector to close the quaternary defect. Third, the additional lobe adds the benefit of another z-plasty, which decreases the tension to transpose the flap, an important advantage when even mild tension at the distal flap can distort the free margins. Finally, the third lobe increases the width of the flap pedicle. If the orientation of the standing cone would cut into the pedicle of a bilobed flap, the increased pedicle size of a trilobed flap can improve blood supply.³⁰



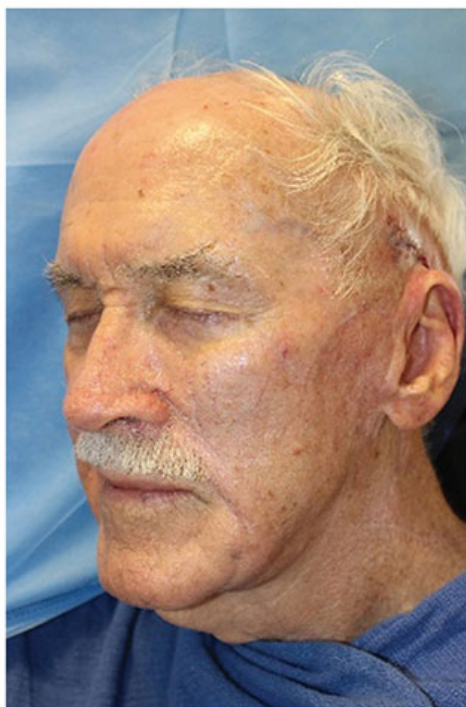
A



B



C



D

Figure 42-27. (A) A trilobed flap is designed to replace this large skin graft. (B) Intraoperative photo demonstrating the degree of flap elevation. Appearance immediately postoperatively (C) and at follow-up (D).

Combination reconstructions

Flap reconstructions for cheek defects borrow tissue from reservoirs that are based inferiorly and/or laterally, potentially producing heavy flaps that are restricted in motion and may pull on the lower eyelid. These factors increase the risk of ectropion from yielding eyelid skin or limit adequate closure of the defect. Attempts to mobilize skin too ambitiously can also result in distal edge necrosis or displace beard hair to sites without hair. Correct flap design, generous tissue release of cheek ligaments, and tacking sutures can help mitigate these concerns in many instances. However, large defects (>3 cm in diameter) and those approaching the lower eyelid frequently benefit from repair with two adjoining flaps or a flap and a graft, rather than a single reconstructive modality.

Multiple flaps

When combining modalities of repair, two or more flaps may be preferred to closure with a flap and graft. The enhanced vascularity and improved color match to the recipient area are more likely to result in improved cosmesis. Combining flaps is most commonly employed when a defect spans two cosmetic units such as the cheek and nose or cheek and eyelid (Fig. 42-28). This combination allows placement of scars at the intervening cosmetic junction such as the nasofacial sulcus, where a shadow is typically expected.



Figure 42-28. (A) Combined rotation and advancement flaps are designed for this medial cheek defect. Appearance immediately postoperatively (B) and at follow-up (C). Combining the flaps preserved the nasofacial sulcus and avoided a larger scar under the eye.

Combined flaps harvest skin from two or more reservoirs and deliver skin to fill a defect that would not be sufficiently covered by a single flap. Cervicofacial rotation-advancement flaps may be a workhorse for large cheek defects, but skin immobility and pivotal restraint limit this flap's movement in younger patients and those without a generous tissue reservoir. In such instances, an inferiorly based V-Y advancement flap may be used to bridge the distance that cannot be closed by the laterally based cervicofacial flap. Skin from the cervicofacial flap's redundant cone is converted to a V-Y flap rather than discarded. Other combined modalities such as adjoining rhombic flaps and double V-Y flaps assist with splitting the distance of large cheek defects.

Flaps with grafts

Zone 1 cheek defects that span eyelid skin are at greatest risk for cicatricial ectropion. The thin skin in this location is loosely draped from the eyelid margin and is susceptible to downward tension vectors, particularly from heavy flaps. Postoperative eyelid descent for large zone 1 defects can be mitigated by combining a flap with a graft. Skin graft interposition between the lid margin and an underlying flap such as a V-Y advancement minimizes the weight and pull on the eyelid (Fig. 42-29). In effect, the full-thickness skin graft acts as a spacer to protect and buttress the lid. Use of flaps with skin grafts may be used for zone 2 and 3 defects but this is typically reserved for instances where alternative reconstructive methods are not possible. The lack of an intrinsic blood supply and use of skin from a distant site during reconstruction with grafts reduces the reproducibility of outcomes and may result in inferior aesthetic outcomes.



A



B



C

Figure 42-29. (A) A V-Y island pedicle advancement flap is planned for the cheek portion of the defect and a full-thickness skin graft is planned for the eyelid portion of the defect. The defect is too tall for coverage from the advancement flap. The full-thickness skin graft acts as a spacer to protect and buttress the lid. Appearance immediately postoperatively (B) and at follow-up (C).

CONCLUSIONS

Key principles of anatomy guide assessment of cheek defects and reconstructive planning. Linear closures, with their consistently reproducible results, minimal morbidity, and ease of execution are generally preferred, though large cheek defects may benefit from flap closure as well. Special attention to the free margins bordering the cheek, such as the lip and eyelid, are of particular importance given their functional and aesthetic value.

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CHAPTER 43 Reconstruction of the Forehead

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SUMMARY

- The forehead, temples, and eyebrows are common locations for nonmelanoma skin cancer and lentigo maligna.
- An array of closure techniques may be used to close defects in these locations, from linear repairs to complex flaps and grafts.
- The eyebrow should be conceptualized as a free margin, and repairs should be designed accordingly.

Beginner Tips



- Linear repairs should always be favored if feasible, but beware of trying to force a linear repair when free margin distortion could result.
- Orient linear repairs along the periocular rhytids for medially located temple defects, and in an arciform pattern close to the hairline for lateral temple defects.
- The benefit of orienting forehead repairs horizontally along the rhytids should be weighed against potential asymmetric eyebrow lifting and the risk of neural compromise.

Expert Tips



- Multiple defects may be repaired with a Burow's advancement flap where the secondary defect is incorporated into the displaced dog-ear.
- An A-to-T design may be preferable to an H-plasty for large forehead defects.
- Defects involving periosteum should first be repaired with a hinge flap.

Don't Forget!



- Vertically oriented forehead repairs may be nearly invisible with outstanding suturing and operative technique.
- The V-Y (island pedicle) flap provides a robust pedicle that is useful for eyebrow and temple reconstruction.

Pitfalls and Cautions



- Facial nerve damage is a risk when working deep in the temple; therefore, such repairs require a thorough appreciation of anatomy.
- Patients should be warned when approaching infiltrative tumors in these locations that permanent facial nerve damage is a possibility.

Patient Education Points



- Always gauge a patient's willingness to undergo and recover from an extensive procedure *before* it is initiated.
- The forehead is highly vascular and postoperative ecchymosis is likely.

- Warn patients that even repairs high on the forehead may lead to a black eye due to a combination of anatomy and gravity.

Billing Pearls



- Most flaps on the forehead are coded with 14040 or 14041, and these codes include the excisional component; it is not appropriate to bill both an excision and a flap repair code simultaneously, except for Mohs excision codes.
- Do not use CPT code 15740 for V-Y (island pedicle) flaps, as this code is only appropriate for flaps based on a dissected and identified named axial vessel.

CHAPTER 43 Reconstruction of the Forehead

INTRODUCTION

The forehead, temples, and eyebrows constitute the upper one-third of the face. This anatomic region is bounded by the hairline both superiorly and laterally, and by the nasal root, orbital rim, and zygomatic arch inferiorly.¹ It is a region commonly afflicted with cutaneous neoplasia and is of considerable functional and aesthetic importance. As such, it is frequently encountered by the reconstructive dermatologic surgeon, where sufficient understanding of local anatomic features, a thoughtful approach to repair design, and meticulous intraoperative technique represent critical determinants to surgical outcomes.

RECONSTRUCTIVE APPROACHES

With a few distinctive caveats, key principles for successful reconstruction of the forehead mimic those of other facial anatomic regions. The forehead is comprised of five cosmetic subunits, including the central forehead, right and left lateral forehead (temples), and right and left eyebrows. While it may be advantageous, or even critical, to confine reconstruction within the boundaries of cosmetic subunits in other areas on the face, there is typically less concern for a repair bridging the cosmetic subunits of the forehead. Instead, reconstructive success is more fundamentally determined by the preservation of forehead subunits in relationship to each other and to the remainder of the facial architecture. Thus, repairs should be designed to

maintain the position of the natural hairline and eyebrows, as these landmarks largely define the visual gestalt of the region.

Additionally, there is considerable individual variation in the amount of non-hair-bearing skin both inferior and medial to the natural hairline, limiting the size of the central and lateral forehead subunits.² Proper consideration of this variable is essential, as the location of the hairline determines the size of potential donor tissue reservoirs for flap repairs and represents an ideal location in which to camouflage incision lines. As with head and neck reconstruction in general, utilization of neighboring tissue, rather than distant skin grafts, is of significant value, as even sizeable flap repairs routinely yield nearly imperceptible scars when appropriately designed and executed.

While the tenet of preserving free margins is inviolable in facial reconstruction, a true free margin—the eyelid—is only occasionally in play when considering forehead defects. That said, the potential to induce lasting eyebrow asymmetry is encountered frequently during reconstructive design. The eyebrows are aesthetically prominent and vulnerable to external tension vectors. Thus, for all intents and purposes, the eyebrows should be considered a free margin, albeit typically a more forgiving one. Thus, it is usually more advantageous to orient a moderately sized primary closure vertically rather than to risk eyebrow elevation with a horizontal approach. Further, there is lower risk for sensory nerve transection with a vertical orientation, and with meticulous suturing technique these scars will typically blend nicely with the surrounding skin.³

Ideally, all repairs should be designed to fall within relaxed skin tension lines (RSTLs), and this precept holds true for reconstruction of the forehead region. RSTLs run in a horizontal arc (perpendicular to the fibers of the frontalis muscle) across the forehead itself, often with a subtle dip at midline where the glabellar musculature pulls overlying skin inferiorly via dermal attachments (Figs. 43-1 and 43-2).

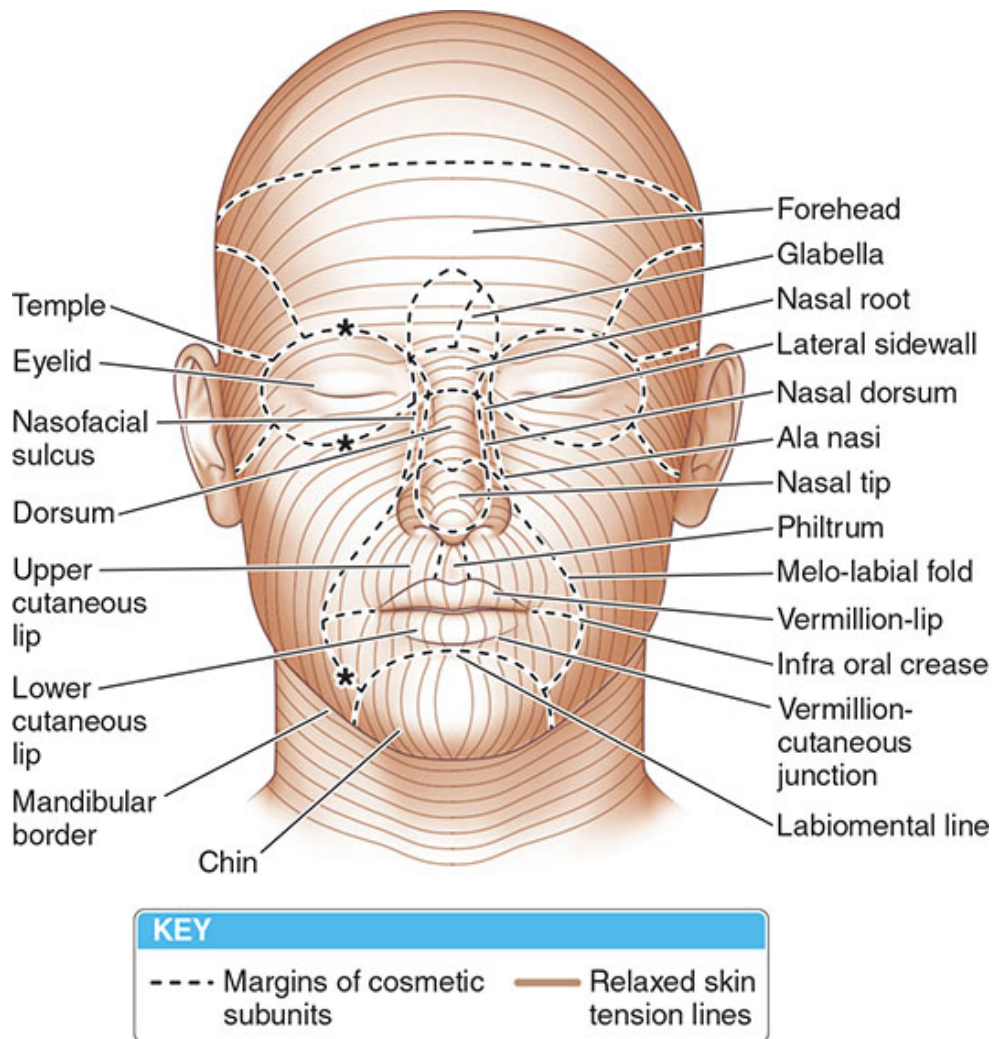


Figure 43-1. The relaxed skin tension lines of the face tend to run perpendicular to the mimetic musculature, with a slight downward pull induced by a gravitational vector.



Figure 43-2. (A) This preoperative photograph illustrates the subtle downward arc often present at midline as the otherwise horizontally oriented RSTLs traverse the central forehead. (B) The defect was horizontally oriented after tumor extirpation. (C) The primary closure was gently curved to fall along this patient's RSTLs. (D) At follow-up, brow position is maintained and incision lines are nicely camouflaged.

When primary horizontal closure is precluded by the location or orientation of a central forehead wound, the glabellar furrows may provide a strategic location in which to hide a vertically oriented curvilinear incision. At approximately the temporal line, the RSTLs begin to curve inferiorly, and in most patients become accompanied by the periocular rhytides, thus allowing incision lines to be thoughtfully placed in a number of orientations. For modestly sized defects located anteriorly on the temple, horizontal repair within the periocular rhytides is often effective, while similar defects located laterally are typically best repaired with incision lines positioned parallel to the natural hairline (Fig. 43-3).



Figure 43-3. (A) While the anterior limb of a horizontally oriented repair could be hidden by this patient's periocular rhytides, a better design choice positions incision lines to fall along the hairline. (B) There is no pull on the lateral canthus at immediate repair. (C) At 3 month follow-up, the incision line is nearly imperceptible.

ANATOMY

An applied knowledge of local anatomy facilitates effective reconstruction of the forehead. This is a region supplied by a robust vasculature emanating from both the internal and external carotid artery systems. From medial to lateral, the main vessels include the dorsal nasal, supratrochlear, supraorbital, and the superficial temporal arteries. The supratrochlear and supraorbital arteries derive from the ophthalmic arterial branch of the internal carotid artery, and exit the skull through the supratrochlear and supraorbital foramen, respectively. These arteries ascend at approximately the level of the eyebrow, passing through the orbicularis and frontalis muscles and continuing superiorly in the superficial subcutaneous tissue.⁴ Extensive anastomoses ensure a robust supply to the forehead vasculature even when one or both of the supratrochlear and supraorbital branches are compromised.⁵ Laterally, the superficial temporal artery, the terminal branch of the external carotid artery, supplies the temple, lateral forehead, and eyebrow, in addition to the scalp. This vessel originates within the substance of the parotid gland and ascends to cross the zygoma anterior to the tragus. The superficial temporal artery becomes invested in the superficial temporal fascia above the zygomatic arch and subsequently gives off the parietal and frontal (anterior) branches (Fig. 43-4). The frontal branch of the superficial

temporal artery runs just beneath the subcutis in the superficial fascia and is easily visualized intraoperatively. It is located just superficial and parallel to the temporal branch of the facial nerve, and thus serves as a rough landmark delimiting the depth to which undermining can safely be performed in this region.²

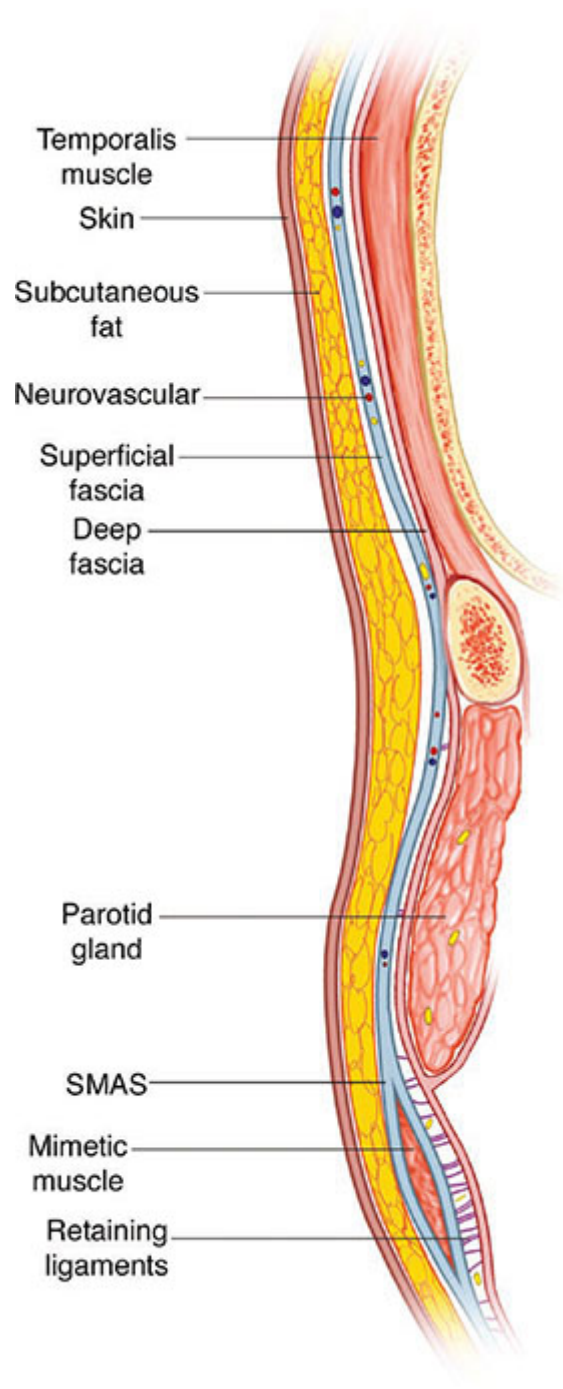


Figure 43-4. Layers of the forehead, coronal view. (By permission of Mayo Foundation for Medical Education and Research. All rights reserved).

The sensory nerves of the forehead region derive from all three major branches of the trigeminal nerve. Medially, the supraorbital and supratrochlear nerves derive from the ophthalmic branch (V1). These nerves exit the cranium and quickly penetrate the musculature, running just above frontalis until they reach the mid-forehead, where they ascend to a more superficial subcuticular level. Surgical transection of the main nerve branches may result in transient or permanent anesthesia and/or significant postoperative pain and lingering neuralgia. As such, horizontal closures should be undermined above the frontalis when possible, particularly on the lower forehead. More laterally, the zygomaticotemporal nerve, derived from the maxillary branch (V2) of the temporal nerve, exits its foramen and pierces the temporal fascia approximately 2.5 cm above the zygomatic arch. This small nerve helps innervate the lateral forehead and temple, where it communicates with the auriculotemporal branch of the mandibular nerve (V3). This latter nerve innervates the upper ear and lateral temple, ascending just anterior to the auricle. Accidental transection of the auriculotemporal nerve may lead to lingering numbness or neuralgia.²

The temporal branch of the facial nerve is responsible for motor innervation of the frontalis muscle. This nerve is susceptible to injury during procedures involving the temple and lateral eyebrow, and thus demands particular attention intraoperatively. Cadaveric dissection has demonstrated that temporal nerve ascends within the innominate fascia just deep to the SMAS over the zygoma, then continues slightly more superficially deep to the superficial temporal fascia.⁶ Upon reaching the frontalis, it courses along the undersurface of the musculature, with smaller branches penetrating superficially. Incisions and undermining anywhere from the zygomatic arch to the lateral eyebrow must remain superficial to the fascia to ensure the nerve is not damaged (Figs. 43-5 and 43-6).



Figure 43-5. Undermining above the temporoparietal fascia ensures the temporal branch of the facial nerve is not injured.

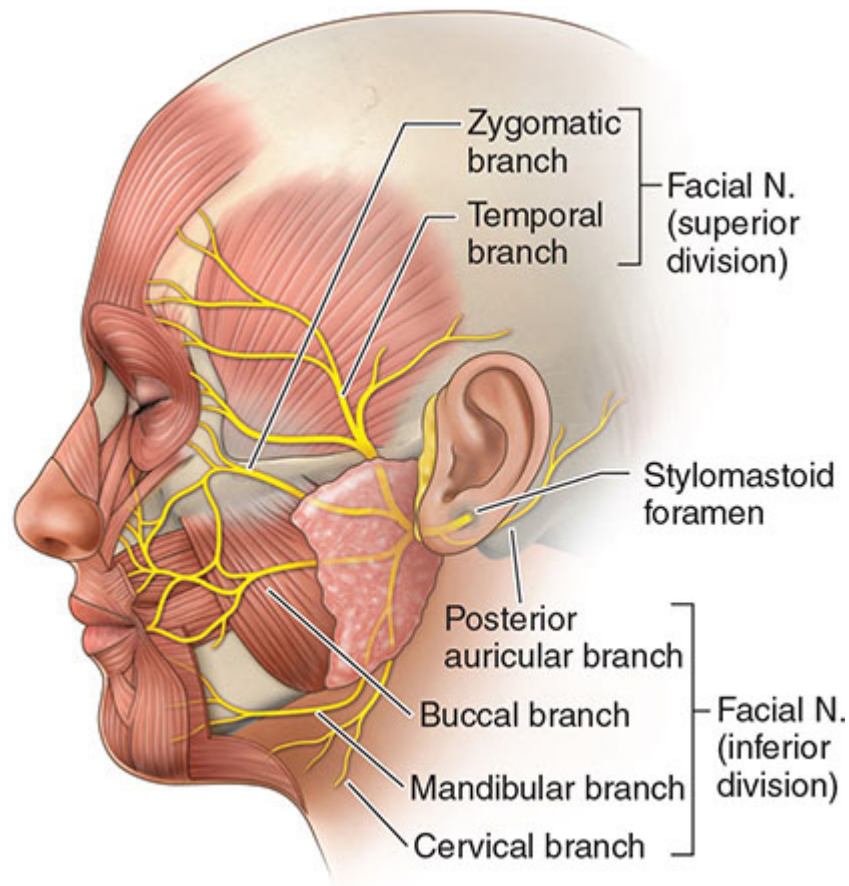


Figure 43-6. The course of the facial nerve.

The mimetic muscles of the forehead include the frontalis, procerus, corrugator supercilii, and the superior portion of the orbicularis oculi. These muscles intercalate with the overlying dermis through fibrous septae spanning the subcutis, thus animating the face. The frontalis is a large, flat muscle traversing the entire forehead. It originates at the superior aspect of the scalp, where its vertically oriented fibers insert directly into the galea aponeurotica, and extends inferiorly to interdigitate with the procerus, orbicularis oculi, and corrugators. Contraction of the frontalis elevates the eyebrows and induces the cutaneous horizontal creases defining RSTLs in this region. The twin corrugator muscles originate from the medial orbital rim just superior to the nose, and insert into the frontalis along with the dermis of the overlying eyebrows. Contraction in conjunction with the procerus muscle pulls the brows medially and inferiorly. The orbicularis oculi is located beneath the eyebrow, deep to the corrugator, and assists in closure of the eye.

There are essentially two potential undermining planes on the forehead, defined by their relationship to the mimetic musculature. A relatively avascular plane exists deep to the frontalis, just above pericranium. Although easily accessible and bloodless, the amount of laxity achieved even with wide undermining in this subgaleal plane is limited. Moreover, horizontally oriented incisions to this depth may damage neurovascular structures. In contrast, undermining in the plane just superficial to the frontalis avoids the transection of larger vessels and sensory nerve bundles while concomitantly permitting substantial flap motion. Surgical technique in this plane must be meticulous, however, to maintain the relatively vulnerable overlying vasculature. Ultimately, the selection of the most appropriate undermining plane is informed by the size and location of the wound in relationship to neurovascular structures and reservoirs of native tissue laxity.

The anatomy of the temple is unique, with important implications in reconstructive surgery. Just beneath what is typically a thin layer of subcutaneous tissue is the temporoparietal fascia, a highly pliable 2–4 mm thick layer of richly vascularized connective tissue that envelops and protects branches of the temporal artery and the temporal branch of the facial nerve. In general, undermining should be performed just superficial to this fascial layer in order to preserve its associated neurovascular structures. Deep to the temporoparietal fascia is a fat pad with associated loose areolar tissue, which provides a relatively avascular plane for deeper resections and for raising a temporoparietal fascial flap (Fig. 43-7).⁷ Deeper still lies the temporalis fascia, the tough fibrous layer covering the temporalis muscle. Superiorly, the temporalis fascia consists of a single layer and attaches to the superior temporal line. Inferiorly, it divides into two layers that insert on the medial and lateral aspects of the zygomatic arch. The temporalis fascia is relatively strong and immobile, and thus may be useful for securing suspension sutures supporting a flap advanced from below. Finally, the temporalis muscle is just beneath the temporalis fascia. The temporalis is a broad, fan-shaped muscle of mastication that arises from the temporal fossa and passes deep to the zygomatic arch, where it inserts onto the coronoid process of the mandible.

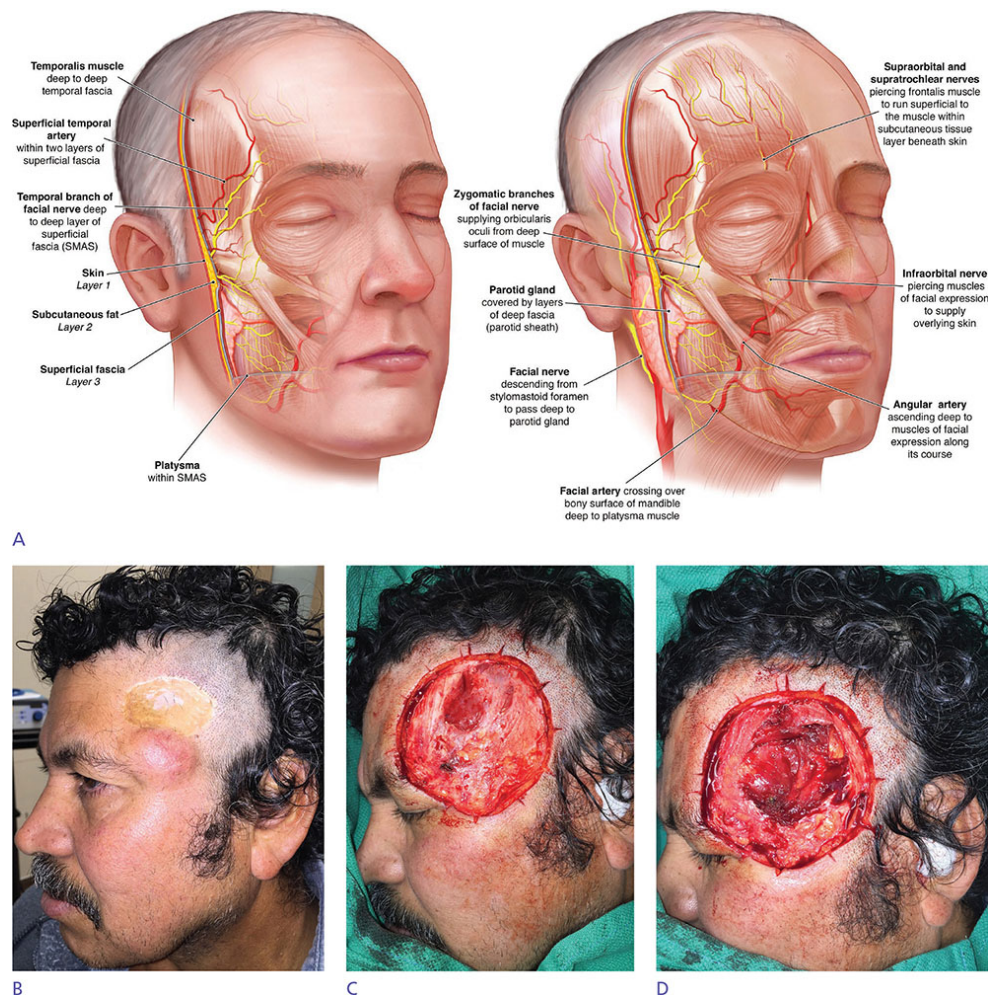


Figure 43-7. (A) Conceptual illustration demonstrating relationship of structures within layers of the face from superficial to deep. (B) This patient presented for Mohs extirpation of a recurrent dermatofibrosarcoma protuberans, which required removal of the tumor bulk inferiorly along with the adjacent split-thickness skin graft. (C) Preoperative MRI indicated the tumor did not penetrate the temporalis muscle, so the first stage was taken at the level of deep temporal fascia, except where the prior graft scar adhered to muscle superiorly. (D) Microinvasive disease was noted to penetrate the deep temporal fascia on frozen sections. A deeper layer including a superficial portion of temporalis muscle was required to clear the tumor, exposing the pericranial origin of the temporalis anteriorly, the muscle itself centrally, and the deep temporal fat pad inferiorly. (By permission of Mayo Foundation for Medical Education and Research. All rights reserved).

RECONSTRUCTIVE TECHNIQUES

Central Forehead Reconstruction

The majority of central (medial) forehead wounds can be closed linearly. Selection of orientation is predicated on maintaining eyebrow symmetry, with consideration given to avoiding injury to sensory nerves. Repairs on the forehead may be undermined in one of two essential tissue planes: just superficial to frontalis or subgaleal. If frontalis and associated deep fascia are divided, they should be reapproximated intraoperatively to mitigate potential scar inversion and/or a depressed *en coup de sabre* appearance that may result from a simple overlying layered dermal repair.² When possible, primary closures should be designed horizontally, albeit with a slight curvature to mimic native RSTLs (Fig. 43-8). For larger defects, particularly those located near the midline (where symmetric elevation of the eyebrows is often tolerable and perhaps even desirable), horizontally oriented closure is preferable (Fig. 43-9). Conversely, vertical closures are less apt to induce damage to sensory nerves, even when the frontalis is breached.



Figure 43-8. (A) Preoperative photograph of a basal cell carcinoma arising along the upper forehead demonstrates the native contour of the patient's hairline, including her widow's peak. (B) The resultant wound involves both the forehead and the frontal scalp. (C) A primary repair was designed along the pretrichial line, with bilateral concave arcs preserving her native widow's peak.

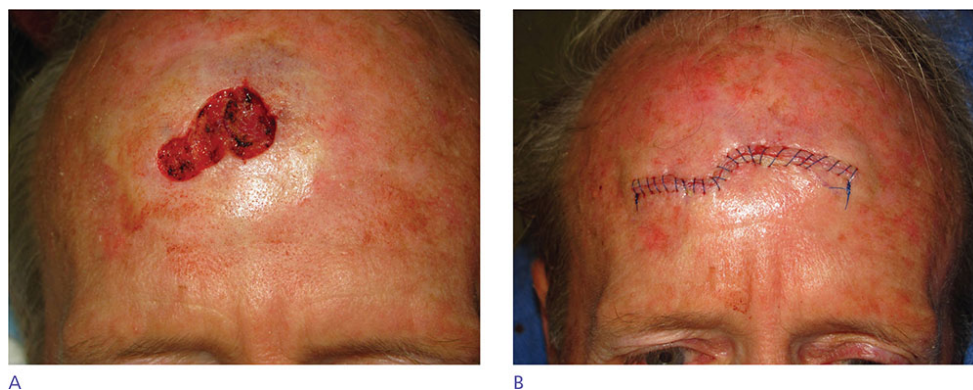


Figure 43-9. (A) This 3.0×1.9 cm mid forehead post-Mohs defect was asymmetric, but primarily horizontally-oriented. (B) In this case, primary closure with two parallel limbs hid the majority of the repair within forehead rhytides while inducing a symmetric brow elevation that was aesthetically pleasing although impermanent.

Advancement flaps are often useful for defects located near the hairline and for larger central forehead wounds, where insufficient adjacent laxity precludes primary closure. The lateral forehead and temple are less bound down to the underlying musculature than is the skin of the medial forehead, and thus many flaps originate from a laterally based tissue reservoir. Medial-based Burow's wedge advancement flaps deriving from the glabella are an important exception, however, and are commonly employed for modestly sized defects of the medial suprabrow (Fig. 43-10).



Figure 43-10. (A) A 2.7×2.8 cm defect of the right medial suprabrow. (B) Medial-based Burow's advancement flap, designed along brow prominence with standing cone removed from glabellar furrow. (C) At 3 month follow-up, note the maintenance of medial brow position and symmetry.

Unilateral advancement flaps provide an uncomplicated means to address many moderately sized defects of the upper forehead, where incision lines may be designed to fall along the natural hairline (Fig. 43-11). This technique may be less advantageous in male patients, however, as gradual recession of

the hairline may lead to greater exposure of scar lines over time. Unilateral advancement flaps are also helpful in repairing larger, vertically oriented forehead wounds, where the horizontal limb may be curved around the orbital rim. On occasion, it may be advantageous to combine multiple forehead defects into a single large but vertically oriented wound in order to facilitate a single advancement repair (Fig. 43-12).



Figure 43-11. (A) This patient presented with a basal cell carcinoma arising along the frontal hairline. (B) While the defect was too large to permit primary closure, it was oriented vertically and therefore amenable to unilateral advancement flap repair. (C) The flap was designed to preserve the silhouette of the patient's hairline while hiding incision lines at the junction of the forehead and scalp.

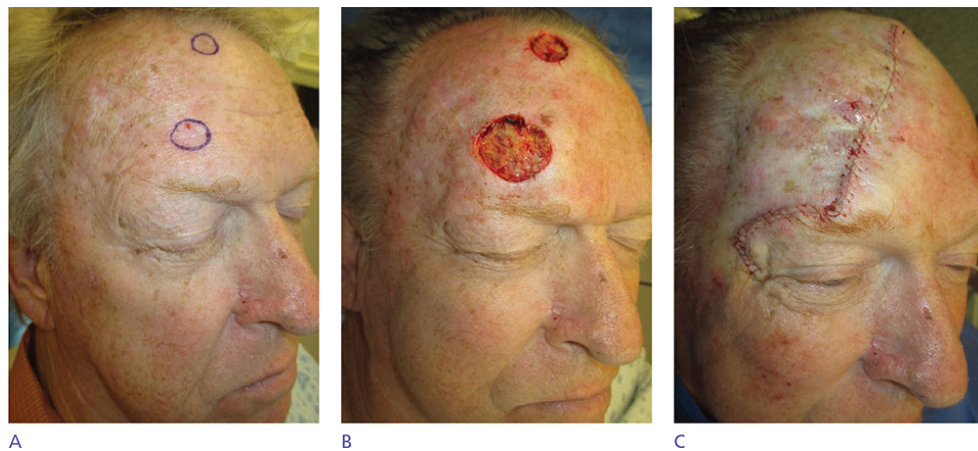


Figure 43-12. (A) Preoperative photo illustrating two tumors of the right forehead. (B) The two moderately sized forehead defects resulting from tumor extirpation were combined into a single vertically oriented defect to facilitate a single advancement flap repair. (C) A laterally-based advancement flap repair permitted both wounds to be closed under minimal tension while preserving brow position.

When insufficient laxity exists lateral to the surgical defect, bilateral advancement flaps allow the surgeon access to adjacent tissue reservoirs on two sides of the defect (Fig. 43-13). Under these circumstances, an A-to-T design may be preferable to an H-plasty as the latter is sometimes less hardy

and may leave a complex, geometric scar. While representing a somewhat inelegant, although occasionally necessary, approach to most wounds of the medial forehead, the bilateral advancement flap is well suited for glabellar defects too large to be repaired linearly. In these cases, an inferior Burow's triangle may be designed to fall within the glabellar furrow, with the remaining two horizontal limbs arched slightly as a bilateral crescentic advancement flap to redistribute any tissue redundancy along the forehead rhytides (Fig. 43-14). Care must be taken to avoid inducing synophrys with this repair.

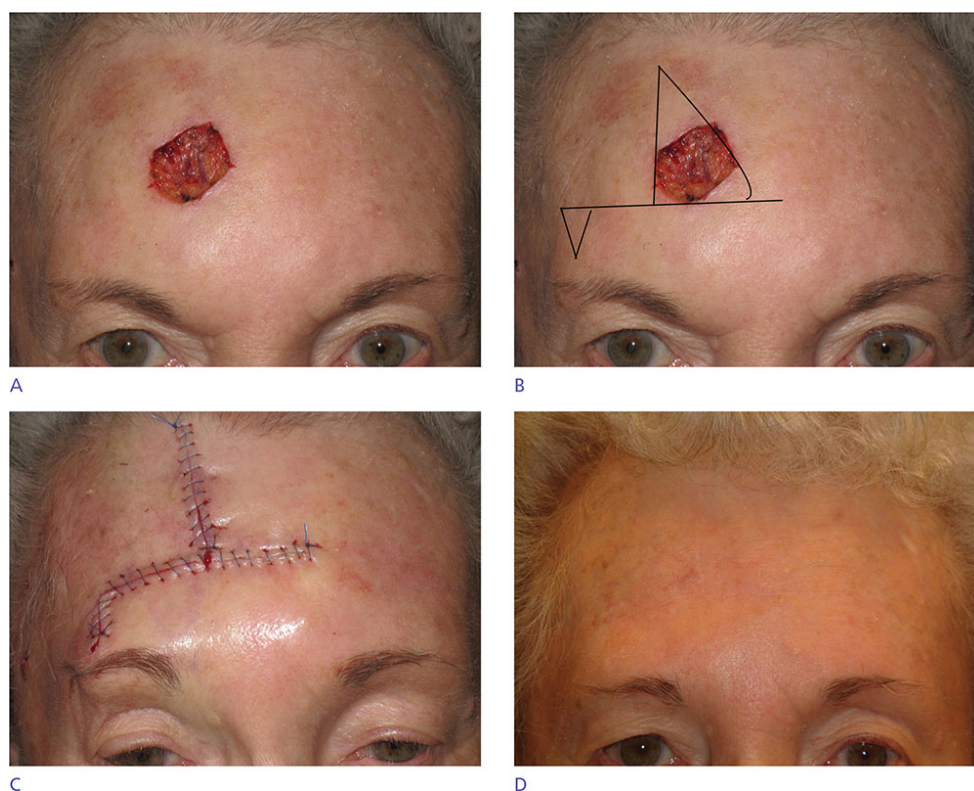


Figure 43-13. (A) A 2.2×1.6 cm wound of the right mid-forehead. Insufficient laxity present laterally necessitated bilateral advancement flap repair. (B) Reconstructive design of A-to-T bilateral advancement flap for repair. Only one Burow's triangle was required inferiorly, and was placed laterally off the central face. (C) Bilateral advancement flap sutured in place. (D) At follow-up, brow symmetry is preserved and incision lines fall well along rhytid contours.

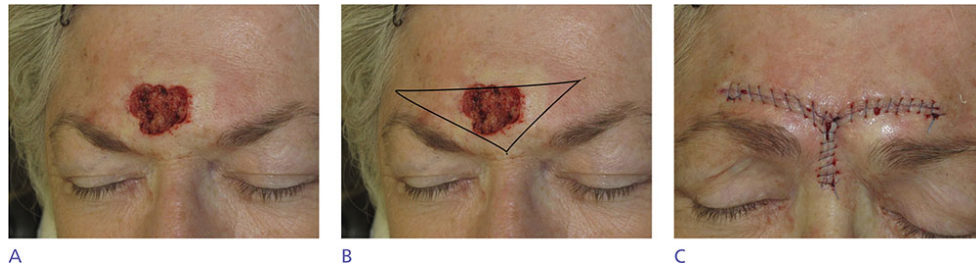


Figure 43-14. (A) This patient with an asymmetric growth pattern BCC of the mid-forehead had a resultant 2.3×1.8 cm defect of the suprabrow/glabella. (B) Design of advancement-rotation flap. Disproportionate upper and lower arcs enabled closure of the horizontal component without the need for removal of tissue standing cones. (C) A bilateral crescentic advancement repair was chosen in order to maintain brow symmetry while hiding incision lines in the glabellar crease and along forehead rhytides. The crescentic component allows standing cones to be distributed evenly along the horizontal portion of the repair, thus preserving the advantageous orientation of suture lines.

True rotation flaps are not commonly utilized on the mid-forehead. They may be helpful for moderate to large defects located along the frontal hairline, where their requisite lengthy arching limbs may be designed superiorly and posteriorly to place scar lines on the scalp rather than on the central forehead (Fig. 43-15). These flaps are raised in the relatively inelastic subgaleal plane and therefore must be appropriately sized to allow for tension-free closure. For large, vertically oriented wounds of the central forehead, bilateral rotation flaps, designed with an inferior Burow's triangle extending down onto the glabella and horizontal arcs placed along the frontal hairline, may represent the only local flap option. These flaps are also raised in the subgaleal plane from the hairline all the way inferiorly to the level of the eyebrows. The galea may be lightly scored to provide further tissue movement if needed, but care must be taken to avoid compromising the flap's subcutaneous vasculature and/or promoting hematoma development.



Figure 43-15. (A) This preoperative photograph demonstrates a basal cell carcinoma arising along the frontal hairline in a 43-year-old female. (B) A 2.8×2.0 cm moderately sized wound involving both scalp and upper forehead. Repair is necessitated to prevent noticeable alopecia in the anterior hairline. (C) A

unilateral rotation flap allowed incision lines to be largely confined to the scalp. These flaps are typically raised in the subgaleal plane and must be adequately sized to allow for low-tension repair.

Horizontally oriented wounds of the medial forehead may be challenging because of their propensity to elevate the eyebrow with simple closure. When located on the upper forehead, these defects may be thoughtfully addressed with a bipedicle advancement flap (Fig. 43-16). This flap is designed as a horizontally oriented linear repair of the primary defect, with a second parallel curvilinear incision made above the primary defect along or behind the hairline.⁸ The secondary incision is made through the galea to release vertical tension. Undermining may be performed in dual planes to further facilitate flap mobility. The superior (secondary) defect allows easy access to the subgaleal plane, where undermining is oriented inferiorly toward the primary defect. The primary defect is then undermined in the supramuscular plane, leading to a musculocutaneous hinge underlying the flap that can more easily be advanced without placing tension on the eyebrow. A periosteal tacking suture secured to the underside of the bipedicle flap may be employed to further reduce pull on the eyebrow. The primary defect is then repaired in standard layered fashion, with the secondary defect repaired similarly, though with the galea left unsutured. When appropriately designed and executed, the bipedicle flap yields reproducibly excellent outcomes for what are otherwise relatively challenging wounds (Fig. 43-17A and B).



Figure 43-16. (A) Recurrent basal cell carcinoma arising along the upper forehead. (B) As anticipated, complete removal of the tumor left a horizontally oriented wound. Preexisting scar tissue resulted in limited vertical closure mobility and excessive brow elevation with manipulation intraoperatively. (C) Bipedicle reconstruction was elected in this case, with the superior incision line placed above the natural hairline, and both carried to the galea and undermined. (D) At follow-up, the natural hairline is preserved, with the inferior scar resembling a native forehead rhytid and neutral brow position.



Figure 43-17. (A) Horizontally oriented defects of the upper forehead may be difficult to close primarily without substantial brow elevation. (B) A bipedicle repair was used here to preserve brow symmetry while placing incision lines just pretrichial and along forehead rhytides. (C) At 1 week after surgery, the eyebrows are symmetric. Notice the biopsy site just beneath the right eyebrow at the location of “a scar from a curling iron burn.” (D) Mohs surgical extirpation resulted in a forehead wound that unfortunately was not amenable to local flap reconstruction. (E) The size of the defect was reduced via partial primary closure, and a full-thickness supraclavicular graft was employed to provide the

remaining tissue coverage. (F) At follow-up, the advantages of utilizing flap repair when possible are apparent.

Skin grafts should be avoided when possible during reconstruction of the medial forehead due to the imperfect color and texture match that have been well described elsewhere. Unfortunately, certain large defects are not amenable to local flap repairs and require grafting. In these cases full-thickness grafting is preferred over partial-thickness grafts when possible so as to more appropriately replicate the characteristics of native forehead skin. It may be helpful to partially close sizeable wounds to confine skin grafts to a single cosmetic subunit and/or to permit full, rather than split-thickness grafting (Fig. 43-17C–F). A niche role for utilizing Burow's grafts does exist on the medial forehead, where graft placement at the glabella can preserve eyebrow separation and thereby facilitate simple vertical linear closure of substantial wounds in this region (Fig. 43-18). Finally, split-thickness grafts may rarely be required when wounds are too large to be repaired with local flaps and when full-thickness grafts are not feasible (Fig. 43-19).

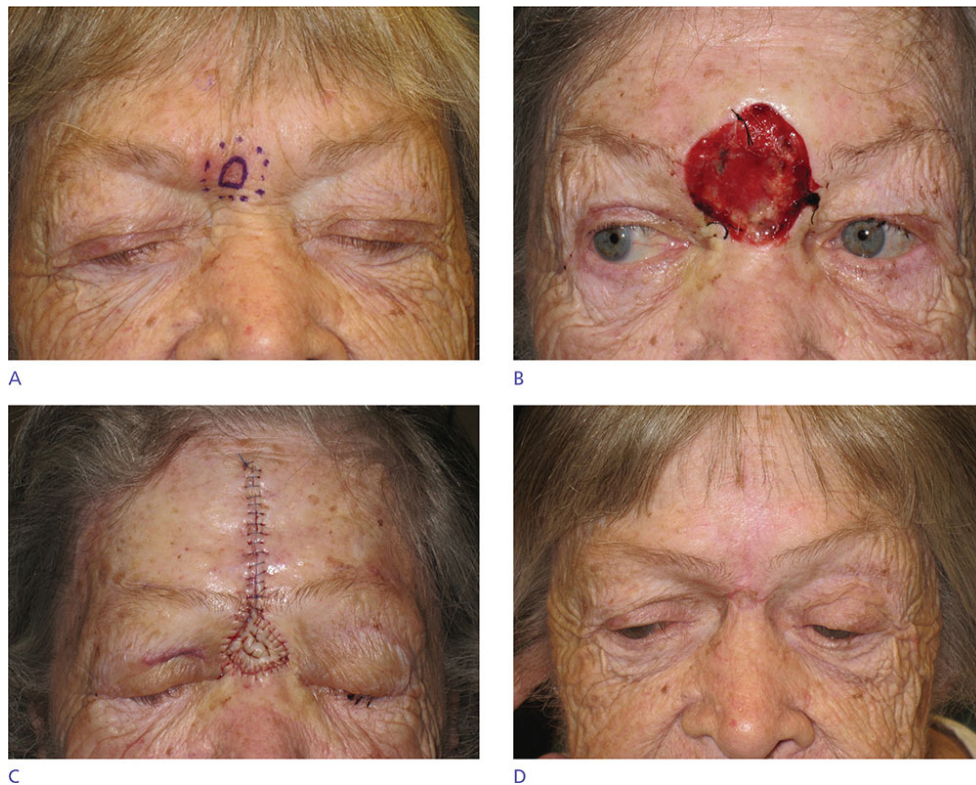


Figure 43-18. (A) This patient presented with an amelanotic melanoma arising on the glabella. (B) The 3.6×3.7 cm surgical defect involved the forehead, glabella, and nasal root. (C) In this patient of

advanced age and multiple comorbidities, a simplistic approach was selected. The forehead portion of the wound was closed primarily, with a Burow's graft used to repair the nasal root. (D) At follow-up the patient's brows have been relocated slightly medially, but the functional and aesthetic outcome is quite serviceable.



Figure 43-19. (A) Preoperative photograph illustrating tumor located at the frontal hairline. (B) Definitive removal resulted in a shallow wound too broad for local flap reconstruction. (C) A split-thickness skin graft provided adequate tissue coverage and expedited healing.

Lateral/Temporal Forehead Reconstruction

Surgical defects of the lateral forehead and temple cosmetic subunit afford multiple options for successful reconstruction. This area encompasses the region from the mid pupillary line to the zygomatic process of the temporal bone, and is bounded superiorly by the frontal hairline and inferiorly by the eyebrow.

Second intention healing may be used successfully for shallow defects of the upper lateral forehead, or smaller defects confined to the relative concavity of the temple. This option minimizes the potential for damage to the temporal branch of the facial nerve by negating the need for further incisions or tissue movement. However, contractive healing in these areas may result in flat or depressed hypopigmented scars which may be accentuated by the light reflex on the forehead's convexity.⁹

Primary wound closure is the mainstay of repair on the lateral forehead and temple, and can be routinely employed for defects less than 1.0 cm in diameter. Fusiform excisions should preferentially be oriented along RSTLs and not result in elevation of the eyebrow (Fig. 43-20). Medially located primary closures should be designed along the frontalis rhytids, while lateral closures should be arcilinear near the temple and horizontal at the lateral canthus/zygoma. Horizontal repairs at the zygoma may also be facilitated by

introduction of an M-plasty to shorten the anterior closure at the lateral canthus (Fig. 43-21).



Figure 43-20. (A) BCC of the left upper temple. Heavily sun-damaged skin reveals prominent horizontal frontalis rhytides. (B) A 2.6×2.0 cm defect of the left upper temple. (C) Horizontally oriented primary closure, designed to keep the maximal portion of incision length hidden within the hairline. (D) Appearance at 3-month follow-up. Note the lack of brow elevation.



Figure 43-21. (A) A 4.1×3.4 cm defect of the right lateral zygoma following Mohs resection of SCC. (B) Design of primary closure with anterior M-plasty. (C) Primary closure of the right lateral zygoma with M-plasty placement to shorten anterior closure length. (D) At 3-month follow-up, incision line hides well in sideburn and M-plasty addition prevents involvement of the lateral canthus.

Closure of smaller defects superior to the eyebrow may be facilitated by uneven undermining of the superior forehead (aggressively) and suprabrow (minimally) (Fig. 43-22). The more superior the defect on the forehead, the less likely eyebrow elevation or distortion is to occur. Fusiform excisions with higher length to width ratios distribute closure more evenly along the eyebrow, and are less likely to result in focal eyebrow distortion.



Figure 43-22. (A) A 1.2×1.0 cm defect of the suprabrow region. (B) Arcilinear excision performed with minimal undermining inferiorly to facilitate edge eversion. (C) Disproportionate undermining performed superiorly.



D



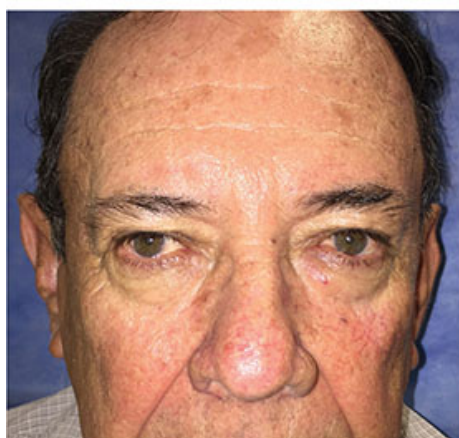
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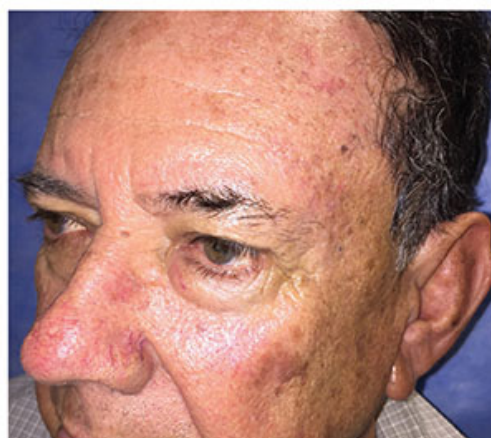
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H



I

Figure 43-22. (D) Greater mobility of superior half tested with skin hook prior to suture placement. (E) Suture placement with no discernable distortion or brow elevation. (F, G) One-week follow-up at suture removal, showing maintained brow positioning. (H, I) Subsequent follow-up.

Larger defects of the lateral forehead and temple are more reliably repaired with cutaneous flaps, which are generally preferable to skin grafts or second intention healing. A variety of adjacent tissue transfer techniques can be employed to include advancement, bilateral advancement, rotation, and transposition flaps.

Advancement and rotation flaps serve as workhorse repairs in the lateral forehead and temple for moderate-sized defects. Single advancement/rotation in one direction is preferable to bilateral tissue movement for reducing incision line profile and minimizing the risk of depressed scars seen in flaps requiring bilateral tissue movement. Design of single advancement flaps should incorporate RSTLs in the horizontal dimension and be hidden along the hairline when feasible (Fig. 43-23).



Figure 43-23. (A) BCC of the left upper forehead in a 46-year-old female with minimal tissue laxity. (B) A 1.4×1.3 cm defect remained on the left upper forehead. The vertical dimension precluded horizontal repair without brow elevation. (C) Unilateral advancement flap design. (D) Advancement flap, designed along frontalis rhytid and hairline. (E) At 3-month follow-up result with no brow distortion or elevation.

Though randomly patterned in design, such single advancement flaps have a robust vascular supply and offer a viable flap that is more apt to survive in individuals with other comorbid factors (such as smoking) which might otherwise predispose them to flap failure. Flap design on the lateral forehead and temple should occur at the level superficial to the SMAS in shallow wounds and under frontalis muscle in deeper defects. This permits placement of a Burow's triangle anywhere along the length of tissue movement. Care must be given in the zygomatic region that flap incision and undermining occur in the superficial subcutaneous tissue to avoid damage to the temporal branch of the facial nerve (Fig. 43-24).



Figure 43-24. (A) A 1.5×1.2 cm defect of the lateral suprabrow. (B) Design of advancement flap. (C) Burow's advancement flap sutured in place. Flap designed along lateral edge of frontalis muscle and Burow's triangle placed in the "crow's feet" laterally. Care must be taken to excise and undermine this

region only in the superficial subcutaneous tissue to avoid damage to the temporal branch of the facial nerve. (D) One week postop at suture removal. (E) Three months postop. No distortion and normal movement of the ipsilateral brow and frontalis muscle.

Simultaneous repairs of multiple defects may be performed using a Burow's wedge flap where the second defect is included in the displaced dog-ear (Figs. 43-25 and 43-26). O-to-T bilateral advancement flaps have good utility along the hairline or lateral sideburn/preauricular region, as the majority of the incision profiles are camouflaged along the hairline/preauricular cheek (Fig. 43-27).



Figure 43-25. (A) Design of a Burow's wedge advancement flap for two adjacent defects on the temple and zygoma. (B) Burow's advancement flap sutured in place.



Figure 43-26. (A) Two BCCs of the right temple and sideburn region. (B) A 1.2×1.2 cm and 1.4×1.2 cm defects of the right temple and sideburn. (C) Burow's wedge advancement flap design with the second defect included within the displaced dog ear. (D) Burow's advancement flap designed to keep majority of incision lines within hairline. (E) At 3-month postop follow-up.



Figure 43-27. (A) Preoperative view of SCC. (B) A 5.1×3.3 cm defect of the right zygoma/sideburn/preauricular cheek following Mohs resection of SCC. (C) Bilateral advancement (O-to-T) flap sutured in place. (D) At 3-month postop follow-up. The patient declined further revision at the site, as the majority of the suture profile is displaced laterally and away from the central face.

Advancement of larger volumes of tissue to the zygomatic cheek and temple is facilitated in V-to-Y (island pedicle) flaps. V-to-Y advancement flaps are judiciously undermined at their periphery, and have a net pushing effect upon closure of the donor site. The robust deep pedicle supports flap viability in deeper defects, which is particularly useful for patients with comorbid conditions that may otherwise predispose to flap failure (Fig. 43-28). Lenticular island pedicle flaps may also be used to recreate the subunit volume of the temple and zygomatic cheek (Fig. 43-29).¹⁰



Figure 43-28. (A) Infiltrative perineural BCC right temple. (B) A 4.5×3.3 cm defect on the right temple through temporalis muscle and periosteum. (C) V-to-Y advancement flap sutured in place. (D) At 3-month postop follow-up. Incision lines remain out of the periorbital aesthetic subunit and are therefore visually acceptable.



A



B



C



D



E



F

Figure 43-29. (A) Recurrent infiltrative BCC following electrodesiccation and curettage. (B) A 7.1×5.0 cm defect of left temple/lateral brow/zygomatic cheek. (C) Design of V-to-Y advancement flap.

Flap designed to incorporate volumetric repair of the temple and zygomatic cheek while displacing the donor-site incisions posteriorly/inferiorly on the preauricular cheek and mandibular ramus. (D) V-to-Y advancement flap sutured in place. (E, F) At 3-month postop follow-up. Good volumetric repair of the cheek and favorable incision placement along cosmetic subunit junctions.

Transposition flaps are particularly useful for reconstruction of the temple, as their design permits the recruitment of the zygomatic cheek tissue reservoir or more lax temporal skin. Multiple transposition flaps may be designed for any given defect. The most appropriate flap design, however, should be the one that mobilizes available skin without cosmetic or functional penalty and places incision lines in the most favorable position (Fig. 43-30). By definition, transposition flaps contain an intrinsic Z-plasty, which also affords redirection of closure tension vectors (Fig. 43-31). Larger defects of the temple may require a transposition flap so large that it would precludes primary closure of the donor site. In such cases, a bilobed or trilobed flap may be utilized to mobilize tissue while redirecting and diminishing the closure tension (Fig. 43-32).

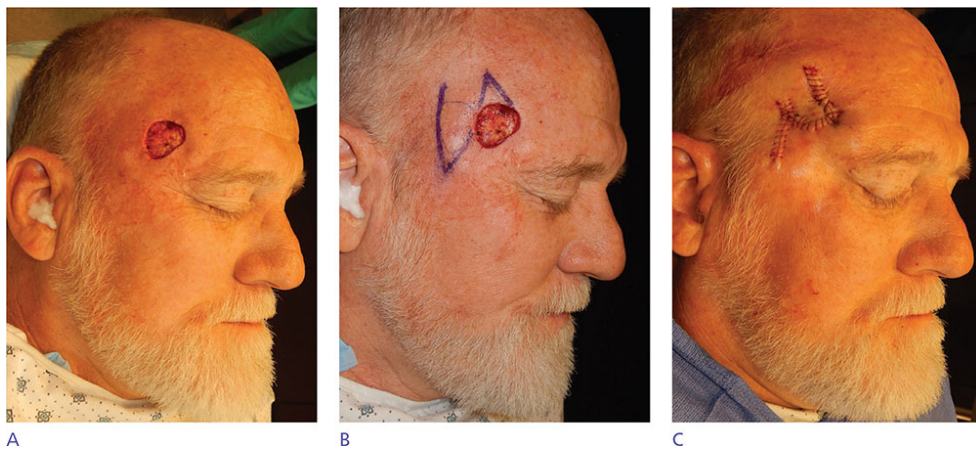


Figure 43-30. (A) A 2.4×2.1 cm defect of the right temple following Mohs resection of infiltrative BCC. (B) Rhombic transposition flap designed with superior pivot point and anterior–posterior closure to minimize traction on the lateral canthus and avoid brow movement. The primary lobule is undersized relative to the defect size to incorporate secondary tissue movement and avoid “pin-cushioning” due to excessive flap fullness. (C) Rhombic transposition flap sutured in place. Notice neutral brow position and no traction on the lateral canthus.



Figure 43-31. (A) A 3.1×2.0 cm defect of the upper left forehead with banner transposition flap designed from the anterior hairline. Though the defect is more horizontal in dimension, primary closure would result in brow elevation. The transposition flap redirects closure tension vertically with no resultant brow movement. (B) Banner transposition flap sutured in place. (C) At 3-month postop follow-up. Flap contours well across the convexity of the upper forehead and results in no brow movement.



Figure 43-32. (A) SCC of the right temple on bed of ill-defined actinically-damaged skin. (B) A 4.7×4.0 cm defect of the right temple and lateral brow. (C) Bilobed transposition flap sutured in place. Tissue recruitment is minimized by introduction of the second lobule in flap design and results in diminished primary closure tension on the lateral cheek.

Skin grafts on the lateral forehead and temple generally have less predictable cosmetic outcomes than cutaneous flaps, but are nonetheless sometimes required for large defects when no appropriate tissue reservoir is available, or in patients who refuse flap closure. Full-thickness skin grafts (FTSGs) tend to offer better texture, color, and thickness match in forehead repair and are generally preferred except with excessive defect size when the decreased metabolic demand of a split-thickness graft would be advantageous. Typical FTSG donor sites for the lateral forehead and temple include the clavicular/supraclavicular region, neck and postauricular area. Adjacent FTSGs (aka Burow's grafts) offer the best reconstructive "match"

and may be used in conjunction with either adjacent primary closure or associated flap design (Fig. 43-33).



Figure 43-33. (A) Infiltrative perineural BCC of the left temple. (B) A 5.3×4.0 cm defect of the left temple, through frontalis muscle with intact periosteum. (C) Burow's advancement flap performed from the lateral temple. Standing cone excision from the superior flap closure was used as Burow's FTSG to the tightest midportion of the flap repair. (D) At 3-month postop follow-up. Patient declined any further revision at site.

Lateral forehead defects which are both large and lack periosteum present a unique challenge for reconstruction. Such complex areas with exposed bone first require transposition of a fascial/muscular hinge flap in order to provide a supportive, viable base for an overlying graft repair. Muscular hinge flaps may be performed in the lateral forehead region from either the temporalis or frontalis muscles (Fig. 43-34).¹¹ Both STSG and FTSG can be supported and remain vitally perfused on the underlying muscular sling transposed into the base (Fig. 43-35).



Figure 43-34. (A) SCC of the right lateral upper forehead. (B) A 8.2×7.0 cm defect of right lateral forehead, through frontalis muscle and lacking periosteum for reconstruction. (C) Arciform parietal excision to elevate skin and permit transposition of a muscular hinged temporoparietal fascial flap across defect base. Scalp subsequently closed and a split-thickness skin graft sutured into underlying hinge flap and defect.



Figure 43-35. (A) Rapidly progressive SCC of the right lateral temple and suprabrow. (B) A 6.3×5.4 cm defect of right lateral temple and brow, through temporalis and periosteum. (C) Temporoparietal myofascial hinge flap. An incision is carried inferior-posteriorly to allow access to the temporalis muscle, which is incised and transposed anteriorly across the periosteal defect and sutured in place. Following development and transposition of a muscular hinge flap consisting of temporalis muscle, a full-thickness skin graft was sutured into the defect peripherally and quilted to the underlying temporalis hinge flap deeply. (D) At 3-month postop follow-up. FTSG shows good take on underlying muscular hinge flap and the patient declined any further revision at the site.

Massive defects of the lateral forehead and temple may require controlled tissue expansion and subsequent repair. Such procedures may be most appropriately repaired under general anesthesia.

Eyebrow Reconstruction

Just as the planning of forehead and temple defect repairs centers around the maintenance of eyebrow positioning and symmetry, reconstruction of the eyebrow subunit itself similarly requires close attention to eyebrow continuity, shape, and positioning.

Second intention healing should be reserved for those defects that are small and extend only into the superficial dermis, so that maintenance of hair regrowth from the hair bulbs can occur. Full-thickness defects will require layered closure, and primary closure remains the mainstay approach for small- to moderate-sized defects. Defects located immediately adjacent to the eyebrow superiorly or inferiorly may be closed with a horizontal arciform primary closure, and hide well along the eyebrow margin (Fig. 43-36). Careful planning may assure that eyebrow closures do not place excessive vertical traction of the upper lid prior to excising the standing cones for primary closure, and that sufficient eyebrow height remains so as not to create eyebrow asymmetry (Fig. 43-37).

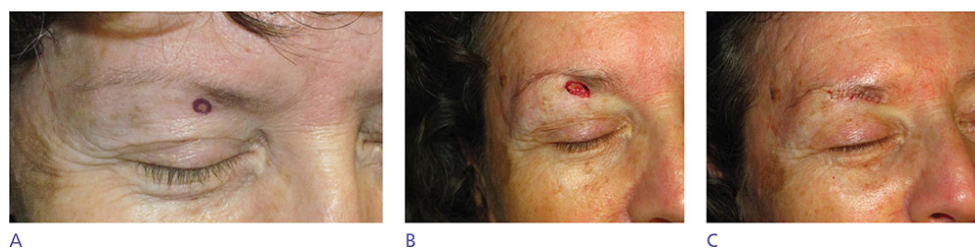


Figure 43-36. (A) BCC of the right mid inferior brow. (B) A 1.1×0.7 cm full-thickness defect of the right mid inferior brow. (C) Primary horizontal closure hidden along the inferior brow margin.



Figure 43-37. (A) BCC of the left lateral brow. (B) A 2.1×1.4 cm defect of the left lateral brow and upper lid. Note the degree of upper lid hooding representing an available tissue reservoir. (C) Arciform linear primary closure demonstrating appropriate laxity for closure and maintenance of brow shape.

Defects with wider horizontal dimension may also be closed primarily in a vertical fashion, and the remaining eyebrow should be marked with a surgical marker prior to local anesthetic infiltration to facilitate ideal alignment and minimize eyebrow distortion. As the eyebrow represents a free margin, vertically oriented primary closures have the tendency to bulldoze the eyebrow and upper eyelid inferiorly upon closure. Therefore, it may be helpful to displace the inferior standing cone deformity across the arc of curvature as it traverses the orbital rim and upper lid. This acts to diminish the degree of tissue pushed inferiorly, as tissue redundancy dissipates over the convexity of the upper eyelid in the manner of a crescentic advancement flap (Fig. 43-38). Medial eyebrow defects may be repaired with vertically oriented closures, as the glabellar crease camouflages the resultant scar (Fig. 43-39).

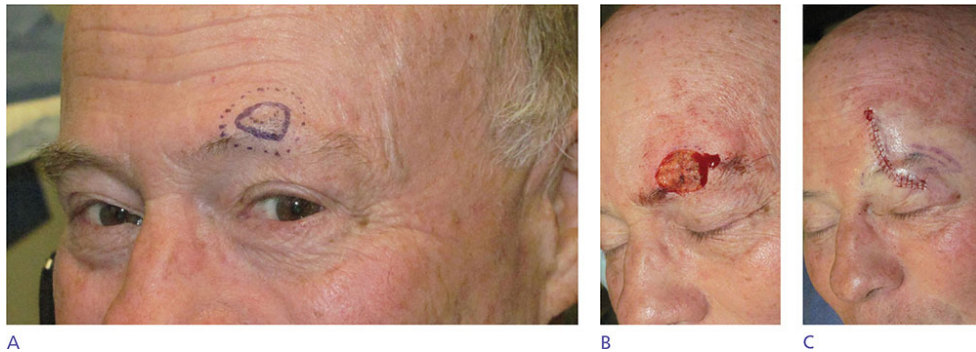


Figure 43-38. (A) MIS of the left mid-brow. (B) A 2.0×1.6 cm defect of the left mid-brow. (C) Vertically oriented closure of mid-brow defect. Note the brow marked for alignment and the arciform curvature designed across the orbital rim to minimize the net “pushing” effect of the vertical closure on the free lid margin.



Figure 43-39. (A) BCC of right medial brow. (B) A 1.1×0.9 cm defect of the right medial brow. (C) Vertically oriented primary closure, recapitulating the procerus rhytid/crease. Note the “pushing” effect at the inferior incision edge. (D) At 3-month postoperative result. Incision hides well in procerus crease and inferior tissue fullness/redundancy has dissipated.

Larger defects in or adjacent to the eyebrow often necessitate adjacent tissue transfer for reconstruction or to minimize deformity of the residual eyebrow. Advancement flaps, whether unilateral or bilateral, are the

mainstay of eyebrow reconstruction, as the majority of the incision profile may be hidden along eyebrow margins. Similarly, advancement flaps offer great utility in minimizing subsequent eyebrow removal or displacement in individuals with sparse eyebrow hair (Fig. 43-40). Flap design along the eyebrow subunit almost always involves elements of both advancement and rotation, which are required to hide incisions along the arc unique to an individual's eyebrow (Fig. 43-41). As with all facial reconstruction, displacement of scar contours or profile laterally allows visual subtraction and a more aesthetically pleasing repair (Fig. 43-42). Both A-to-T and H-plasty variations may all be useful advancing flaps within the eyebrow. V-to-Y flaps offer the additional benefit of moving a residual hair-bearing island on a well-perfused deep vascular pedicle into alignment with the remaining medial eyebrow (Fig. 43-43).



Figure 43-40. (A) BCC of the right mid-forehead. Note the sparse eyebrow hair present and absence of lateral brow. (B) A 1.4×1.2 cm defect of the right mid-forehead. Horizontal closure would result in brow elevation and vertical closure would result in removal of sparse brow hair. (C) Advancement flap sutured in place to hide incision along the frontal bossing ridge and displace the standing cone deformity laterally on the brow avoiding further loss of eyebrow hair. (D) At 3-month postop follow-up. Note symmetry of brow and salvage of medial brow hair.



A



B



C



D

Figure 43-41. (A) A 2.5×2.1 cm left suprabrow defect in a 46-year-old female patient with minimal tissue laxity/rhytides. (B) Burow's advancement flap sutured in place. Careful attention to brow positioning must be given during flap design. (C, D). At 3-month postop result. Good maintenance of brow positioning and symmetry.



A



B



C



D

Figure 43-42. (A) MIS of the left medial suprabrow. (B) A 4.2×3.4 cm defect of the left medial/mid suprabrow. (C) Advancement flap sutured in place with laterally displaced Burow's triangle. (D) At 3-month postop result. Good preservation of brow positioning and symmetry due to lateral displacement of standing cone deformity to the "crow's feet" rhytides.



Figure 43-43. (A) BCC of the right lateral brow in a 52-year-old woman with minimal rhytides/skin laxity. (B) A 1.1×1.0 cm defect of the lateral brow. (C) Design of V-to-Y advancement flap. (D) V-to-Y advancement flap sutured in place. Careful alignment assured by premarking brow margins prior to tissue advancement.

Wider defects of the lateral eyebrow may require transposition flaps for recruitment of tissue to fill the defect. In such cases, the repair may not reintroduce eyebrow hair, but instead attempts to minimize lid contraction postoperatively, and diminish the risk for ectropion formation (Fig. 43-44). In surgical repairs that do not preserve or recreate eyebrow hair, transplantation may be performed in the postoperative period. The occipital neck and sideburn are both potential donor sites which may serve as good matches for the residual eyebrow.^{12,13}



A



B



C



D

Figure 43-44. (A) Perineural SCC of the left lateral brow and temple. (B) A 6.3×6.0 cm defect through temporalis muscle involving the lateral brow, temple, and upper lid. (C) A rhombic transposition flap, incorporating laxity of the lateral cheek and preauricular skin, was planned. (D) Transposition flap from the lateral cheek/zygoma sutured in place.

CONCLUSIONS

Reconstruction of the forehead and eyebrows is frequently performed by dermatologic surgeons. As with all reconstructive approaches, linear repairs may be the most straightforward, though flaps are often necessary in order to restore normal anatomical form and function. Appropriately orienting linear closures, and wisely selecting from an array of flap repair choices, may help create the ideal closure for the patient and minimize the risk of functional or cosmetic compromise.

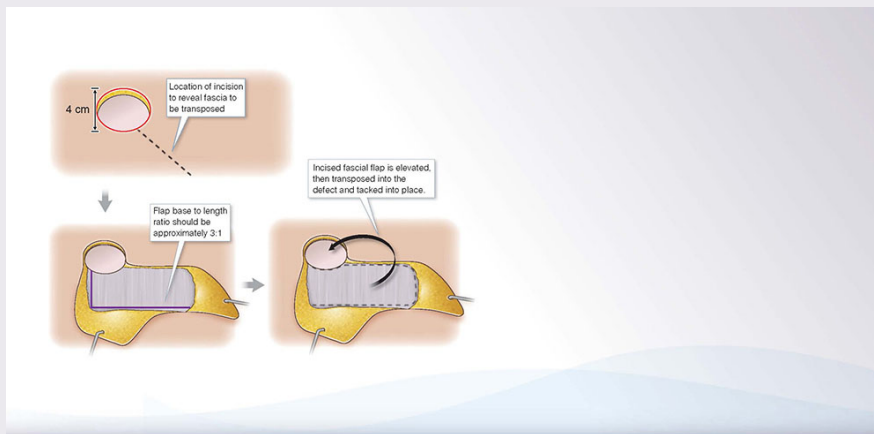
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CHAPTER 44 Reconstruction of the Scalp

David G. Brodland



SUMMARY

- Repairs on the scalp may be complicated by relatively inelastic skin and thin dermis that conspire to make closures challenging.
- Secondary and tertiary intention healing are frequent options on the scalp, though primary linear closure is preferred when feasible.

Beginner Tips



- Assess the degree of possible tissue movement prior to local anesthetic infiltration.
- Attempt to minimize the volume of local anesthetic infused into scalp skin, and consider placing direct pressure on the area after infusion to avoid overestimating the degree of tissue inelasticity.

Expert Tips



- Superficial excisions on the scalp kept in the suprafollicular plane may heal well via secondary intention healing.
- Fascial transposition flaps may be used as an alternative to hinge flaps to provide a vascular bed when periosteum has been removed.

Don't Forget!



- Nerve blocks may be helpful in minimizing the volume of local anesthetic used for select defects.

- If a wound fails to show any progress over a 2-week period, assess what is leading to this stagnation and make changes accordingly.

Pitfalls and Cautions



- While dog-ears on the scalp tend to resolve spontaneously, concavities do not. Therefore, when using split-thickness skin grafts consider tertiary intention healing to provide time for robust granulation tissue, and thus reconstructive thickness, to form.

Patient Education Points



- Patients have variable levels of concern regarding scalp aesthetics; be sure to address this prior to the initiation of surgery.
- The scalp healing process may be very time consuming. Patients and their caregivers should be warned about this well ahead of time, and their willingness to undergo a lengthy wound care regimen must be ascertained.

Billing Pearls



- Scalp grafts may be coded with the 15120 and 15220 for split- and full-thickness grafts, respectively. Xenografts may be coded with 15275.
- When repairing a scalp defect with a combination flap and graft, both codes may be used. Flap codes may not, however, be combined with linear repair codes.

CHAPTER 44 Reconstruction of the Scalp

INTRODUCTION

Reconstructive surgery on the scalp is frequently performed by dermatologic surgeons. Malignancies on the scalp may frequently become large, as they are located on surfaces that are not regularly seen by the patient and that may be covered by hair, often delaying recognition and diagnosis. Additionally, there are unique characteristics of scalp skin and soft tissue that should be considered when designing a closure ([Table 44-1](#)).

Table 44-1. Key Considerations for Scalp Reconstruction

Feature	Significance
Aesthetic concern	Directs the focus of and the extent of the reconstructive effort
Depth of wound	Second intention may be ideal for superficial wounds
Presence of adjacent hair-bearing skin	Represents potential source of scar camouflage May indicate a more delicate dermis unable to withstand tight closures
Scalp mobility	Dictates flap types that may be feasible
Intrinsic elasticity	Dictates flap options
Tensile strength of dermis	Determines the quantity of wound tension that is tolerable

GENERAL CONSIDERATIONS

The scalp has several unique characteristics that may dictate decisions for optimal wound management. First, there is a diverse level of aesthetic concern among patients: A surprising number of patients have a low level of concern regarding scalp appearance, particularly when compared to more visible areas of the face such as the nose, cheeks, or lips. Therefore, wound management is often profoundly influenced by the aesthetic expectations of the patient (Table 44-2). Furthermore, function is rarely a concern for the scalp, and so a substantial proportion of patients are content to simply camouflage otherwise noticeable scars with adjacent hair.

Table 44-2. Wound Management Based on Aesthetic Expectations

Aesthetic Concern	Wound Management			
	Second Intention	Graft	Primary	Tertiary
Low	+++ Given longer period of wound care, can exceed aesthetic expectations	++ STSG and pinch grafting provide lower aesthetic result but are ideal in terms of ease of procedure and after care	++ Always a reasonable option unless patient prefers second intention	+++ May exceed aesthetic expectations and shorten after care
High	+ ■ Can satisfy high expectations if wound is superficial ■ Preserved follicles	++ ■ When primary closure not possible can provide satisfactory result ■ FTSG provides superior cosmesis when possible	+++ ■ First choice if it can be accomplished ■ Up to 2.5 cm in diameter with normal laxity	+ ■ Delayed closure plus "lesser" aesthetic result limits value

Another unique characteristic of the scalp is that hair-bearing skin heals nicely without any reconstruction if the wound can safely be kept superficial enough that the hair follicles are preserved and can regrow. As the hair regrows, it may completely camouflage a scar that would otherwise be noticeable in non-hair-bearing skin (Fig. 44-1).¹



Figure 44-1. (A) Second intention wound scar 1 year postoperative after suprafollicular tumor excision. (B) Regrowth of hair through scar provides excellent cosmetic result.

Scalp skin is among the thickest of the body; it is inelastic, immobile, and difficult to work with during reconstruction. It typically has limited reservoirs of adjacent lax skin to be used as donor skin. Paradoxically, despite its thickness, one of the scalp's unique features is that the dermis is often relatively thin or lacks the tensile strength necessary to withstand the very high tensions that may be needed to suture wound edges. Bald scalp dermis is frequently thinner than expected, while hair-bearing skin lacks durability and may tear under high tension with large gauge sutures due to the high follicular density. These characteristics vary dramatically from person to person, and must be carefully assessed prior to planning the reconstruction.

The importance of complete removal of a skin cancer of the scalp cannot be overemphasized. Aggressive and metastatic scalp tumors may be a function of the abundant blood supply of the scalp or the greater likelihood of delayed diagnosis. There is a tendency to remove tumor with narrower margins than recommended when performing a standard excision, likely given the challenge that an immobile and inelastic scalp wound poses for closure. Therefore, the tissue sparing qualities of Mohs micrographic surgery may be particularly useful on the scalp. Furthermore, safely removing tumor

with relatively superficial depth is enabled by Mohs surgery, which may obviate the need for reconstruction entirely if the wound can be allowed to heal by second intention.

PREOPERATIVE ASSESSMENT

Preoperative assessment for scalp wounds is important for several reasons. First, patients' diverse aesthetic goals are of critical importance; since function is rarely a primary issue, aesthetics is the key preoperative consideration. In discussing, comparing, and contrasting possible closure options, many patients opt for the less complicated choice. If Mohs surgery is being performed, this information can guide the surgeon on the depth of excision. In a patient preferring a less complicated closure, attempting a more superficial excision may increase options once the cancer is cleared. On the other hand, if a patient favors immediate closure, there may be little advantage to sparing subcutaneous tissue, and excision to fascia is reasonable.

The second important assessment to be made preoperatively is the intrinsic elasticity and mobility of the skin. Scalp skin is typically unforgiving and inelastic. However, some patients do have substantial elasticity and mobility, affording more options for closure, such as adjacent tissue transfer. Preoperative assessment in the outpatient setting is key, as once the skin is infiltrated with local anesthetic, the tissue's true elasticity becomes more difficult to assess.

SURGICAL APPROACHES

Several broad categories of scalp closure may be entertained: closure by second intention and its variations, closure by grafting, primary closure, and flap closure. Wound management by second intention, however, does not imply that the wound is not surgically manipulated in some way. In addition to simply bandaging the defect, other techniques may enhance the rate of wound healing, as well as its final appearance. Options for graft closure of the scalp include not only full-thickness skin grafts (FTSGs) or split-thickness skin grafts (STSGs) at the time of the surgery, but also delayed grafting (a form of tertiary intention closure). As such, second intention

closure options can be used in concert with grafting techniques. While flaps may be performed on the scalp, the unique composition of the scalp skin and its workability may limit the utility of select flaps.

Second intention healing

The simplest approach to scalp wound management is wound closure by second intention. As such, it is important to understand the relative and occasionally absolute indications and contraindications for selecting this option (Table 44-3).

Table 44-3. Algorithm for Selecting Second Intention Wound Healing

No	Yes
■ Primary closure can be easily performed ■ Patient expresses preference for closure ■ Patient expresses specific preference not to manage with second intention wound healing ■ Bleeding problems ■ History of poor healing ■ Pre-existing erosive pustular dermatosis (EPD) ■ Impending condition associated with poor healing—chemotherapy ■ Poor social support—unable to perform wound care	■ Prefers no additional surgery ■ Scarred scalp ■ History of radiation ■ Poor donor site availability militating against primary closure—actinic keratoses (AKs), adjacent malignancy, and EPD ■ Dementia—combative—likely to manipulate bandages

The first step in selecting second intention wound management is patient education (Fig. 44-2). If the patient indicates a preference for allowing the wound to heal by second intention and there are no contraindications, then this option is an excellent choice. When the scalp is scarred from previous

procedures or injury, or if it is completely inflexible, second intention wound healing should also be considered. When the adjacent tissue that would be used for the primary closure is unacceptably compromised either from severe actinic damage, other skin cancers, or inflammatory conditions such as erosive pustular dermatosis, then healing by second intention becomes an ever more attractive option.



Figure 44-2. (A) Preoperative melanoma of the scalp. (B) Post Mohs defect. Patient expressed strong preference to allow the wound to heal by second intention. (C) Partial closure reducing area by >50%. Wound is packed with gel foam. (D) Long-term follow-up with acceptable result.

There are additional occasions when circumstances favor less surgery, such as in a combative patient with dementia who is expected to or known to remove bandages and excoriate or mutilate the wound. If for any reason it is in the patient's best interest to delay primary closure, or if the decision to perform primary closure cannot be made at the time of surgery, second intention wound healing is preferred.

Relative contraindications for second intention wound healing include cases where primary closure would be technically straightforward and would shorten the time to healing. A closed wound in a patient with known thrombophilia or who is on anticoagulants may be preferable to reduce the chance of postoperative bleeding. Some patients with a known tendency for extremely prolonged wound healing of the scalp should also be considered for primary wound closure. Second intention wound healing is typically more labor intensive for the patient and, if their social support situation is not conducive to adequate wound care over prolonged periods of time, second intention wound healing may be impractical. Similarly, this approach is inadvisable when patients are undergoing chemotherapy, are neutropenic, or have compromised wound healing. Thus careful consideration of the patient's health, social situation, and other unique nuances may assist in the decision regarding second intention wound management.

Second intention healing and ancillary augmentation techniques

Optimizing wound care is of vital importance once a decision to allow the wound to heal by secondary intention is made. Adjustments in the routine wound care may need to be made based on the details of both the health of the patient and the nature of the wound, though typical wound care consists of daily bandage changes and very gentle cleansing of the wound (Table 44-4). The basic bandage is a nonstick dressing placed over the ointment-covered wound base and affixed with adhesive tape, if possible.

Table 44-4. Three-Step Standard Occlusive Wound Care

-
1. Cleanse wound with tap water
 - Can be done while showering
 - Roll a moistened cotton tip applicator
 - Pat the wound and surrounding skin dry
 2. Apply ointment base to wound or bandage
 - Petrolatum-based ointment
 - Antibiotic ointment for wounds >1 month duration
 - Clotrimazole ointment or equivalent twice weekly when antibiotic ointment is used for >1 month
 3. Cover wound with nonstick gauze and affix with paper tape
 - Repeat once daily
 - May reduce frequency to every other day at 2–4 weeks
 - Consider switching to hydrocolloid bandage after suppurative phase
-

Daily bandage changes are performed carefully to avoid injury to the newly formed epithelium growing in from the margins. Likewise, cleansing of the wound itself is performed gently with tap water. If the patient showers daily, cleansing can be conveniently done in the shower. After several weeks, in a normally healing wound, every other day bandage changes may be feasible and even beneficial by lessening incidental trauma to the regrowing epithelium. Similarly, hydrocolloid dressings can be substituted for daily dressing changes once the wound becomes less suppurative, generally after 2 to 3 weeks. These bandages may be left in place for up to 7 days and are most feasible on bald scalps. They should only be used if they can be kept on the wound for at least three consecutive days.

Scalp wounds are sometimes treated with topical antibiotic ointments, such as mupirocin. With longstanding wounds (over 1-month duration), prophylactic anticandidal ointment may be added to mitigate the risk of yeast overgrowth.

Ancillary techniques are available to augment and abbreviate second intention healing. These include reducing the size of the wound with partial closure, and covering or filling the wound with skin substitutes that may enhance and stimulate healing.

The simplest wound augmentation technique is reducing the size of the defect with sutures (Fig. 44-3). If a wound cannot be reduced in diameter by 50% or more, the degree of benefit from partial closure diminishes.

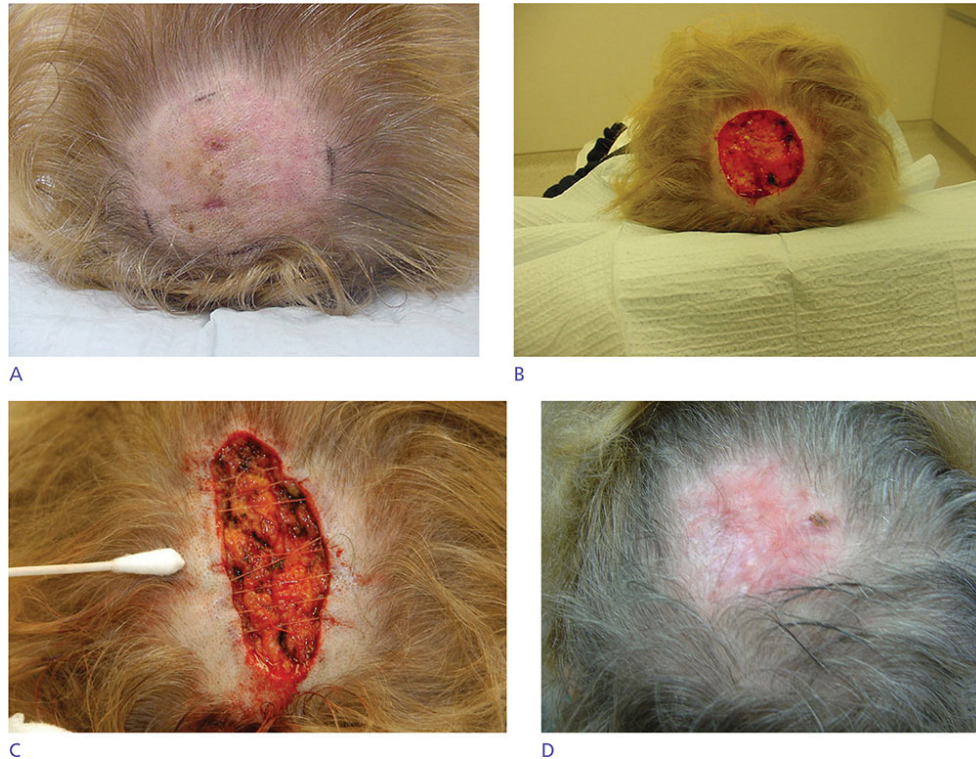


Figure 44-3. (A) Large melanoma of the vertex scalp. (B) 7.5-cm defect post Mohs surgery. (C) Greater than 50% reduction of wound by a combination of mechanically advantaged suture technique and dermal horizontal mattress sutures. (D) Healed wound 2 months postoperatively.

Partial closure may be effected in several ways. The first is placement of buried horizontal mattress sutures across the wound (Fig. 44-4). Scalp dermis is variable in its tensile strength and is occasionally fairly atrophic. Densely hair-covered dermis is also often less able to withstand high-tension suture placement. The order of suture placement may have an impact on closure success (Fig. 44-5). Placement of the first suture on one end of the wound, and working along the wound to the other end will allow greater approximation of the wound, using a zipper-like effect.

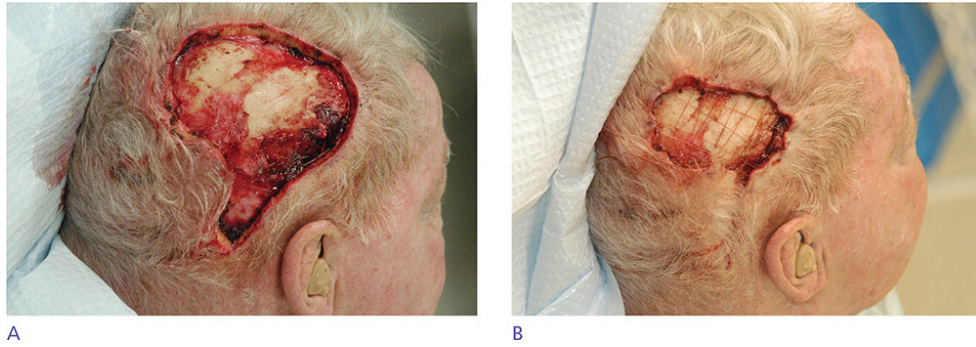


Figure 44-4. (A) Large defect after Mohs excision of squamous cell carcinoma. (B) Partial closure of defect and substantial reduction of remaining wound with buried horizontal mattress sutures. The resulting wound is allowed to heal by second intention. Wound was packed with gel foam.

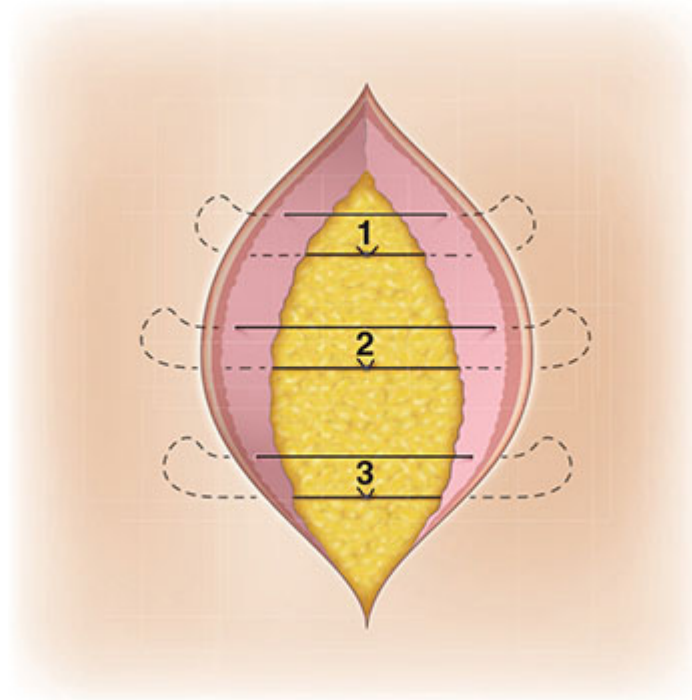


Figure 44-5. Order of suture placement for ease of technique.

Another technique for wound approximation involves the use of a pulley or double suture technique. Several variations of this approach are possible, including the mechanically advantaged suturing technique with a series of four horizontal mattress sutures where the suture material loops in the center (Fig. 44-6), but all confer the mechanical advantage of a pulley that ultimately permits better tissue movement.

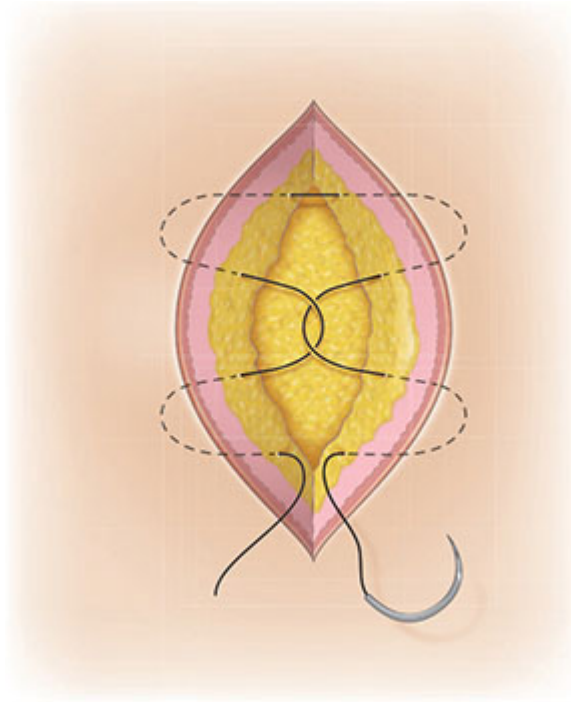


Figure 44-6. Diagram of mechanically advantaged suture technique which consists of four buried horizontal mattress suture bites with a central interlocking suture which forms a dynamic pulley system. The pulley provides a 2:1 mechanical advantage.

Another helpful technique to reduce the overall size of scalp wounds is the purse-string suture (Fig. 44-7). Once all sutures are placed, the wound edges are pulled centripetally together, though without mechanical advantage. Various other techniques, such as the guitar-string suture technique, are available as well.

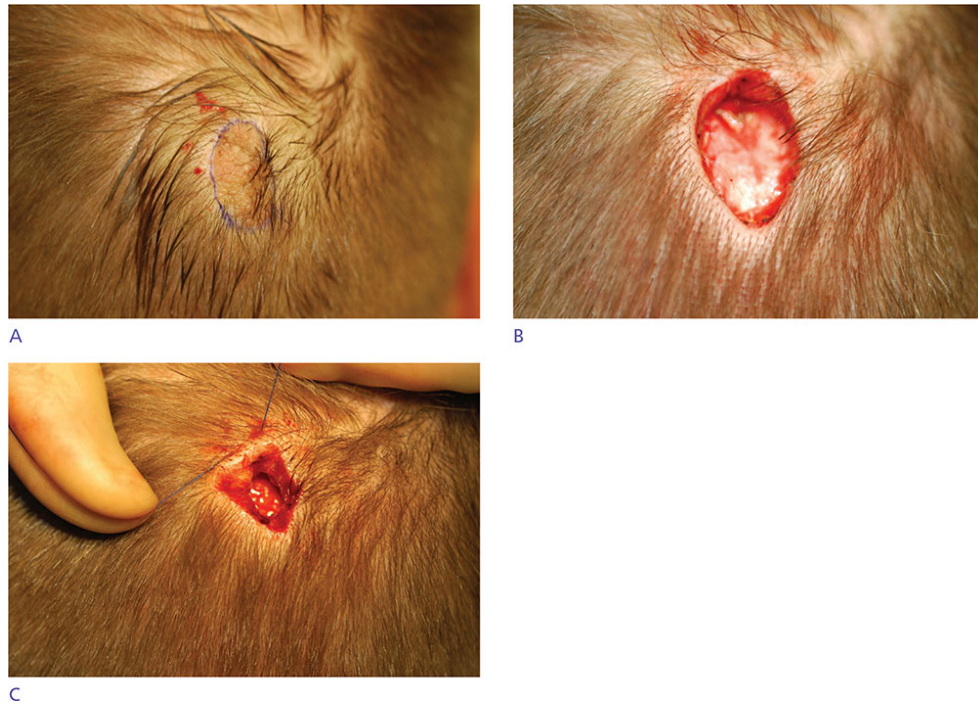


Figure 44-7. (A) Preoperative excision of basal cell carcinoma arising within a nevus sebaceous. (B) Postexcision of tumor. (C) Substantial diminution of defect using purse-string suture technique.

Another way to augment second intention wound care is with epidermal or dermal substitutes. They may be used in wounds partially closed with one of the aforementioned suturing techniques, or independent of any previous wound closure. These skin substitutes effectively provide a covering to the wound base and may induce more rapid granulation and healing. Secondary benefits of these products include improved hemostasis and exudate control postoperatively, less burden on the patient for wound care, and some protection of the wound base from external factors.

Epidermal substitutes, most typically porcine xenografts or cultured epithelial autografts, function to induce and enhance granulation tissue formation (Fig. 44-8). The placement of the xenograft is technically straightforward, and entails simply trimming it to the size of the defect or, in larger wounds, placing multiple xenografts over the base of the wound in a patch-work fashion. In wounds that are partially closed, the xenograft can be inserted beneath the sutures. Thereafter, nonstick gauze is placed over ointment, and a bolster dressing is applied. After bolster removal 1 week later, daily to every other day, bandage changes are initiated using standard occlusive wound care. The xenograft can be debrided in 3 to 4 weeks, and

standard occlusive wound care is continued until healed or, alternatively, delayed FTSG can be considered.

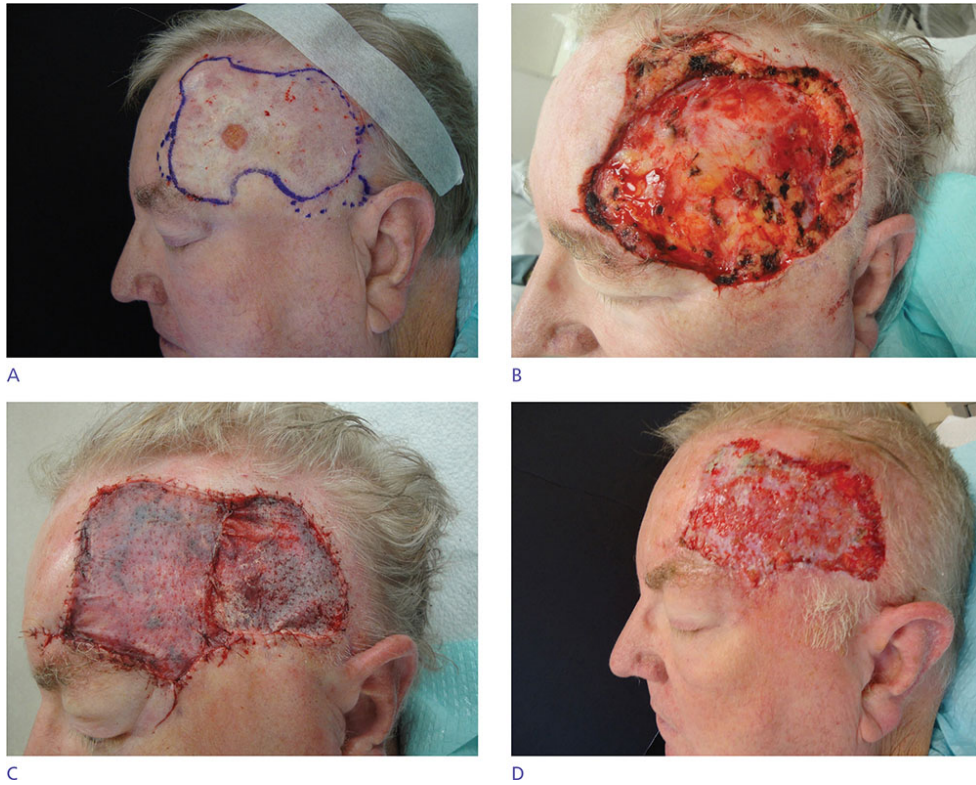


Figure 44-8. (A) Large basal cell carcinoma of the left temporal scalp and temple preoperatively. (B) Post Mohs excision defect. Some follicles were preserved in the posterior temporal scalp wound. (C) Preliminary coverage with xenografts over the entire wound to induce more rapid granulation of the wound. (D) Three weeks postoperatively xenograft debried exposing excellent granulation tissue. (*continued*)

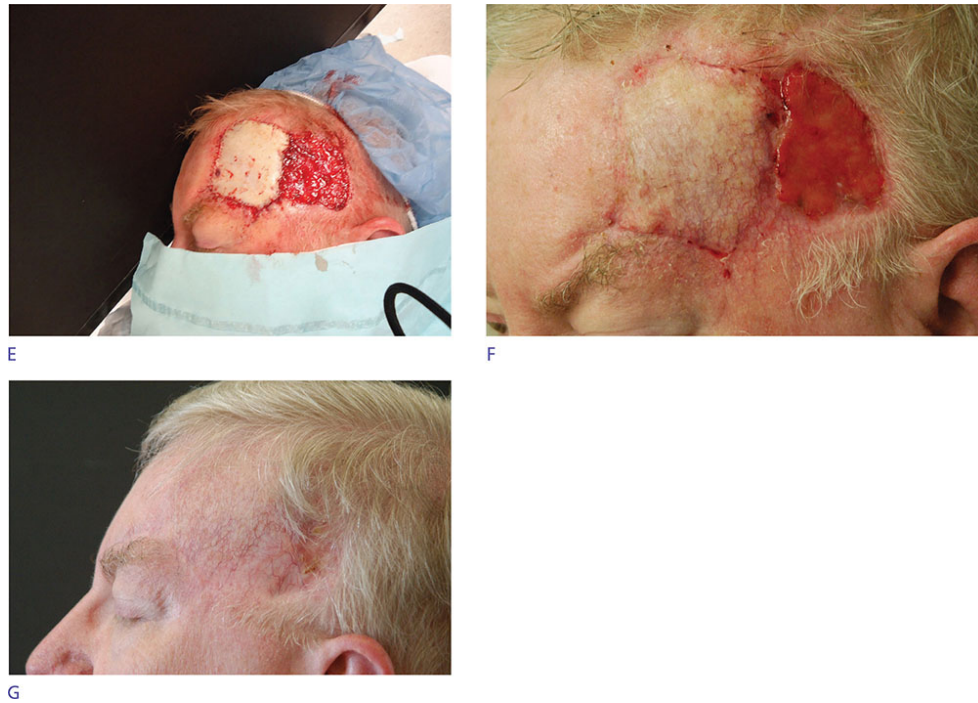


Figure 44-8. (E) Partial closure of the forehead and temporal portion of the defect with full-thickness skin graft. Second intention healing of temporal scalp was planned with hopes of some hair regrowth. (F) One month post grafting with notable peripheral reepithelialization of second intention wound. (G) Six months postoperative with excellent healing of both graft and second intention wound with regrowth of some hair in the posterior aspect of the wound.

Dermal substitutes may also be placed into the wound, and can be held in place with sutures or overlying dressings for up to a week. Thereafter, standard occlusive wound care can be initiated. Unlike xenografts, it is expected that the dermal skin substitutes will become incorporated into the wound, and therefore debridement is not necessary.

Dermal skin substitutes may also be beneficial in very deep wounds. These products are generally used to replace the full-thickness of skin and improve the quality of the scar once healed. These are left in the wound to be incorporated in the healing process. Some are bilayered with a deep bovine collagen and glycosaminoglycan dermal layer and an overlying silicone sheet which must be removed at approximately 3 weeks. This can be an elegant way to speed healing dramatically. These products may be costly however, and are reliant on an adequate vascular base.²

Defects that extend to bone, where periosteum is no longer present, may not readily form granulation tissue. When failure to form granulation tissue is confirmed, cautious chiseling of the outer table of the bone using a bone

chisel and mallet may effectively expose a vascular supply derived from the bone and facilitate formation of granulation tissue. After partial removal of the outer table, pinpoint bleeding is observed signifying accomplishment of the goal. Less than 1 mm of the outer table is typically removed (Fig. 44-9). The chiseled area is then immediately covered with ointment and occluded using standard occlusive wound care. An alternative to standard occlusive wound care for these wounds is the use of a hydrocolloid dressing changed every 7 days. Granulation tissue formation tends to be more rapid and exuberant with these dressings in slow-to-heal, desiccated wounds. Buds of granulation tissue are expected within a few weeks and they continue to proliferate, ultimately creating a vascular base that can then be resurfaced either with a delayed graft or naturally by marginal reepithelialization.



Figure 44-9. (A) Preoperative multiply recurrent basal cell carcinoma. (B) Post Mohs excision requiring removal of periosteum as well as a bone layer using decalcification techniques with micrographic surgery. Denuded portions of the bone have been chiseled to pinpoint bleeding. (C) Six weeks postoperatively with excellent early granulation arising from exposed bone. (D) Three months postoperatively with complete granulation coverage of exposed bone. The wound went on to heal entirely by second intention.

Recent reports of air embolism after chiseling the outer table of the bone underscore the caution necessary for this procedure. If chiseling of the outer table is deemed necessary, it should be performed with the patient in a flat or reverse Trendelenburg position, and the wound should be immediately and completely occluded with ointment and bandages. The reverse Trendelenburg position decreases the chance of negative pressure formation at the chiseled surface, which can draw air into the vascular system and create air emboli. Likewise, immediate occlusion serves to seal the vascular channel and diminishes the chance of this complication. Nonetheless, this technique should not be utilized without due consideration of these potentially serious complications.

Full-thickness skin grafts

FTSGs are often very effective for reconstruction of the scalp (Fig. 44-10). Although they do not replace hair, they may be highly aesthetic for reconstruction of a bald or balding scalp. Results following full-thickness graft procedures may be durable, and are accomplished with relative ease (Table 44-5).

Table 44-5. Approaches to Skin Grafts on the Scalp

	FTSG	STSG	Pinch Graft
Clinical qualities	Contains adnexae conferring normal skin texture More likely to be normally pigmented Provides greater thickness Durable	Adnexae absent causes smooth, shiny texture Often hypopigmented Partial-thickness replacement skin Less durable	Focal islands containing some adnexae and dermis Cobblestone pattern Focal epidermal replacement Intermediate durability
Donor site	Supraclavicular fossa Postauricular Upper inner arm Adjacent scalp	Postauricular Mastoid Clavicle Thigh Scalp	Clavicle Thigh Scalp
Technique	Full-thickness excision to SQ Fat is trimmed from base Circumferential suturing Basting sutures Tie-over bolster dressing	Freehand Weck blade Mechanical dermatome	Freehand 5–10 mm Circular to oval partial-thickness Tangential island of epidermis and upper half dermis



Figure 44-10. (A) Post Mohs excision of basal cell carcinoma of the left vertex. (B) Full-thickness skin graft placed. (C) Two months postoperative with excellent healing of the graft which is inconspicuous because of adjacent hair regrowth.

The FTSG procedure begins with identifying the most appropriate donor site, which may be any area with sufficient laxity to permit closure following graft harvest. Consideration of thickness, quality, and textural match of the scalp skin is important. The most readily available donor site with excellent tissue match is the supraclavicular fossa. This area provides ample donor skin, which is relatively thick, durable, and elastic, and tends to match scalp skin well, especially in the bald scalp. A template is made of the defect and used to precisely score the donor skin surface. Typically, a 90-degree incision to the fat is made along the score line. Upon removal, the fat is trimmed from the undersurface of the graft with scissors. The graft is then placed in the wound, tacked into place, and circumferentially sutured into the wound.

There are several simple principles that optimize the chances for complete survival and cosmesis of a graft. The first of these is to obtain a correctly sized graft. Oversizing the graft is not recommended as the texture and turgor of the engrafted tissue will not appear normal. Similarly, a graft

that is undersized may be too thin, or may result in tension-related graft necrosis at the margins. For these reasons, a template is made of the wound and used at the donor site to precisely incise a correctly sized graft.

The second key principle is ensuring that the graft is immobilized and remains in contact with the wound base during the first week to optimize the inosculation phase of engraftment. This can be accomplished with either quilting sutures or a bolster dressing. The graft can be quilted to the underlying wound base by absorbable sutures placed through the undersurface of the graft and then into the corresponding area of the wound base. Alternatively, these sutures can be placed through the surface of the graft into the wound base after the graft has been sutured. Both techniques serve to affix and secure the graft to the wound base. Alternatively, a bolster dressing is perhaps the simplest method to maintain complete contact of the graft to the wound base. This can be accomplished by covering the graft with nonstick gauze followed by fluffed gauze. Sutures are then placed across the bolster from one side of the wound to the other. Larger wounds may require several of these crossover sutures to ensure adequate and evenly distributed compression of the graft against the wound base. Regardless of the method, the essential principle of these techniques is to ensure that the wound base and graft remain immobilized and in contact with the wound without shearing motion during the early phase of engraftment. Any part of the graft that is not in direct contact with the vasculature of the base will not survive.

Split-thickness skin grafts

STSGs have special attributes that may be beneficial in the repair of scalp wounds. Their advantages include a low metabolic requirement for engraftment, leading to higher rates of graft survival. Large wounds can be covered, since harvesting large grafts is relatively simple (Fig. 44-11). Donor site wound care is straightforward, as it is managed by standard occlusive wound care technique. STSGs diminish the immediate postoperative risks of bleeding and the more long-term risk of delayed wound healing compared to wounds allowed to heal by second intention. Wound care of the graft itself is relatively simple for the patient, since the bolster dressing remains in place for 7 days, after which a second bandage is applied for the second week. Thereafter, the well-healing graft is kept moist with daily application of ointment or moisturizers.

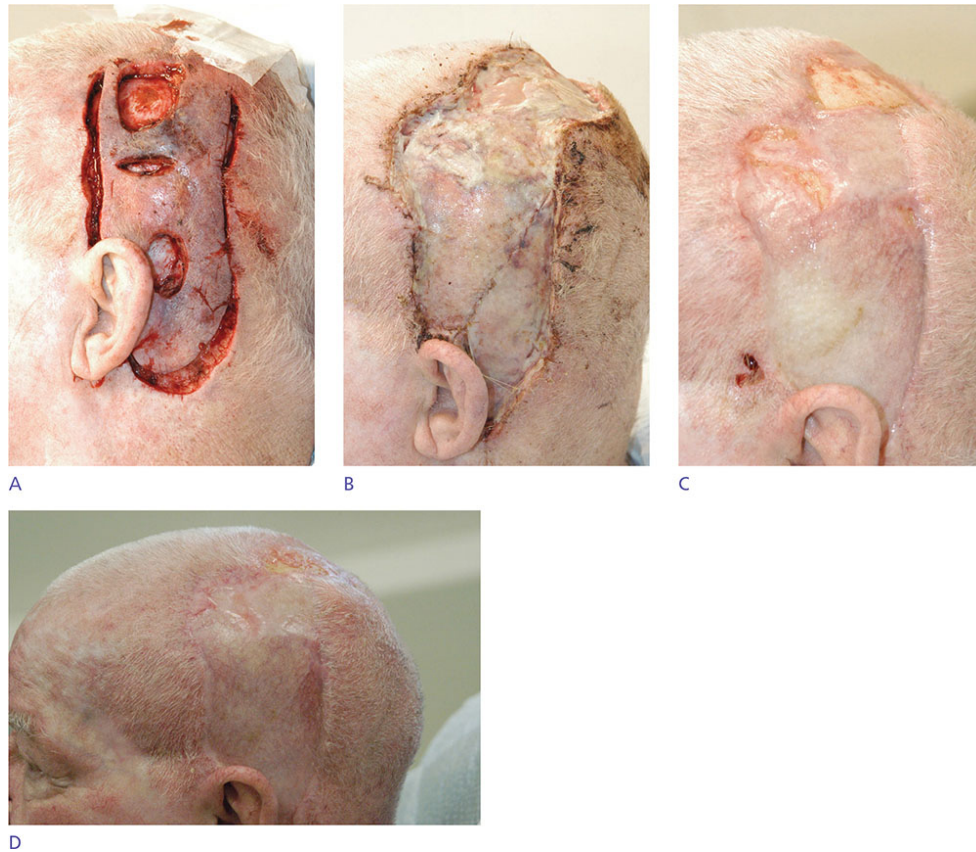


Figure 44-11. (A) Preoperative excision of large infiltrative squamous cell carcinoma. (B) Two weeks after placement of split-thickness skin graft harvested from the anterior thigh. (C) Six weeks postoperatively. (D) Three months postoperatively.

There are also disadvantages inherent to the STSG. First, they are by definition partial-thickness skin replacements that are used for full-thickness skin loss. Therefore, both the aesthetics of the repair and the durability of the healed skin may be suboptimal (Fig. 44-12). Often, a healed STSG remains depressed below the natural contour of the surrounding scalp, and the grafts typically become hypopigmented and have no appreciable texture or adnexae. STSGs mandate the creation of a second wound necessitating several weeks of wound care. Donor wound sites are often painful initially and, on occasion, are complicated by postoperative bleeding. The wounds also generally heal with a hypopigmented scar. They rarely become hypertrophic because of their very superficial nature. Another potential disadvantage of STSG is the requirement for a mechanical device for harvesting, requiring set up and technical training.

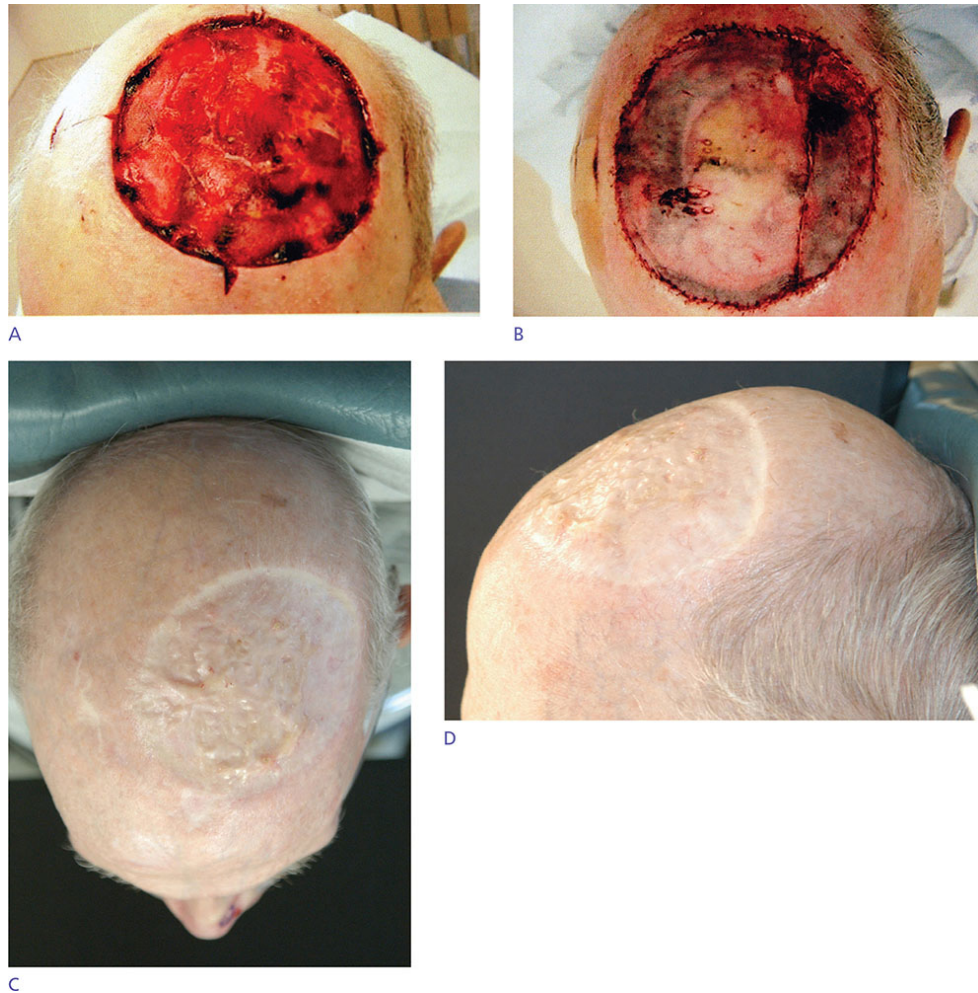


Figure 44-12. (A) Postoperative defect after Mohs excision of microcystic adnexal carcinoma of the left frontal and parietal scalp. (B) Large split-thickness skin graft sutured into place. (C,D) Follow-up at 2 years.

There are three fundamental methods of STSG harvesting. The first is freehand harvesting by the surgeon using a scalpel or razor blade held tangentially to the skin. This technique is effective for smaller grafts, though, they are typically thicker and more variable in thickness than those harvested using a device. The other two techniques involve using a separate device. These include nonmotorized devices such as the Weck blade, or motorized dermatomes such as the Paget or Brown dermatome.

Weck Blade Technique

The Weck blade includes a handle with a single-edged blade and a blade guard designed to produce grafts of varying thicknesses. The thicknesses

typically range from 0.08 to 0.18 in. The blade guard is approximately 4 cm in width and, as a result, grafts up to approximately 3 cm can be easily harvested.

Potential Weck blade donor sites include the skin overlying the mastoid process, the occipital scalp, the clavicle, and the mid to upper anterior or lateral thigh. The scalp donor site rapidly reepithelializes due to the high density of hair follicles, and is often used repetitively as a donor site in burn victims. The mastoid process and clavicular skin are excellent sources of skin, and the underlying bony structure makes the harvest easier for smaller grafts. The convex surface of these areas also makes more precise sizing of the graft easier. On less rigid surfaces such as the thigh, it is helpful for both the surgeon and assistant to retract in opposite directions along the direction that the graft will be harvested, compressing the soft tissue by squeezing deeply to increase the convexity of the donor skin during graft harvest. This permits the width of the graft to be easily varied by the surgeon. A wider graft will be obtained with more downward pressure placed on the Weck blade, and a narrower graft is harvested with less downward pressure. Training and experience are very beneficial, and result in more precisely shaped and sized grafts.

The technique for the Weck blade harvesting begins with prepping the skin and local infiltration of the skin with anesthetic. The area to be harvested can be marked or templated and prescored with a scalpel using the template. Once the donor site is prepped, the skin is lubricated with mineral oil, nontoxic soap, or ointment. The device is placed at one end of the donor site and angled at 30 degrees to the skin. Constant downward pressure is applied to the blade throughout graft harvesting. The surgeon's nondominant hand is then placed on the opposite side of the donor site and traction is applied away from the Weck blade device. When the donor site is a softer area such as the thigh, it is helpful to have an assistant providing countertraction in the opposite direction of the surgeon's hand. The graft is then harvested using a back and forth sawing motion of the device, which is kept at a 30-degree angle to the skin throughout the procedure. Once graft harvest begins, it must continue until the graft is entirely harvested as it is not possible to reposition the blade and resume harvesting once the blade has been lifted from the skin. Upon complete separation of the graft, the Weck blade is pulled back in the opposite direction, and the graft is severed at the terminal end of the donor

site by a scalpel or scissors. The graft is then cleansed to remove lubricant and transferred to the wound.

Once transferred, care is taken to ensure that the undersurface of the graft is in contact with the wound base and the graft is gently unfolded and distributed across the wound. It can then be tacked into place and trimmed to fit the wound.

Once circumferentially sutured, the graft can be further secured to the wound base either by tacking sutures or tie-over bolster dressings. Vaseline impregnated gauze is also useful and can serve as both a nonstick surface and bulk for bandaging.

Motorized Dermatomes

Motorized devices such as the Paget or Brown dermatome are also useful for harvesting STSGs of precise thicknesses. The blade guard width and thickness is often adjustable, making these devices customizable. The maximum width of the graft varies between machines, but is generally larger than the Weck blade. As such, the usual donor site is the mid to upper anterior or lateral thigh. Again, once graft harvesting begins, it cannot be suspended and restarted. Upon separation of the graft, the dermatome is withdrawn and the graft is detached with scissors or scalpel. The graft and dressing are applied as above.

Pinch Grafts

Pinch grafting is a simple variant of grafting that results in a hybrid graft with characteristics of both STSGs and FTSGs.^{3,4} The technique is simple but effective for certain clinical scenarios. Though this is not usually a first-line approach, it is an excellent option for situations where a more involved procedure is not feasible or contraindicated. Furthermore, the resulting wound at the donor site is rarely an issue for the patient or their caretakers.

Pinch grafts are useful for large wounds that would benefit from second intention healing, but would take an extended period of time to heal without a reconstructive assist. Patients with a history of slow-healing wounds on the scalp or lower legs by second intention may benefit from pinch grafting. A patient unwilling or unable to tolerate a more extensive or prolonged procedure similarly may benefit from the very brief period of time required for harvest of pinch grafts.

If there are concerns about the patient's ability to care for wounds, pinch graft donor site wounds are at low risk for postoperative complications and are very easy to care for. Over the long term, skin quality—including thickness, durability, and pigmentation—is closer to a FTSG than an STSG. Initially the grafted areas often display a cobblestoning effect, which improves with time.

The technique involves a scalpel or razor blade and forceps, and pinch grafts are typically 4 to 10 mm in size. The most common donor site is the anterior or lateral thigh, though skin overlying the clavicle or mastoid, or even the tissue surrounding the defect if definitively cleared with Mohs surgery, are also appropriate donor sites.

After prepping the donor site, circular or oval, partial-thickness shave excisions are performed (Fig. 44-13). The thickness of the grafts may be variable, as thinner graft donor sites heal more quickly and the grafts themselves have lower metabolic requirements. With these characteristics in mind, a tangential excision of a thickness ranging from less than a millimeter to 2 mm can be obtained. Local anesthetic infiltration of the donor site skin immediately prior to harvesting causes increased turgor, permitting the graft to be immediately, tangentially excised before the swelling subsides. The graft is transferred to the wound or kept on saline soaked gauze while subsequent grafts are harvested. The number of grafts needed varies based on the size of the wound and the goals of reconstruction. However, for small- to moderate-sized wounds, placement of the grafts within 1 cm of the scalp wound margin and then spacing them 5 to 10 mm apart is the usual grafting pattern. Once all grafts have been placed, the recipient wound is very carefully covered with petrolatum gauze. Care is taken to not displace the grafts during bandaging as they are not sutured into place. The goal is to immobilize the wound, and the grafts will become adherent to the wound within a few hours. Once covered with gauze, a bulky dressing is applied over top and normally affixed and immobilized through adhesive taping. If there is concern about the security of a taped bolster, a tie-over bolster dressing is reasonable and will assure immobilization of the graft. No additional wound care is needed and the donor sites are cared for with standard occlusive wound care. The patient returns in 1 week for careful removal of the dressing. The wound bed and margins are gently cleansed with water and petrolatum gauze is reapplied with a clean bulky dressing and left in place for one additional week. Thereafter, standard, daily occlusive

wound care is initiated until healing is complete. The islands of epidermis and dermis quickly begin to expand and coalesce over the next few weeks until reepithelialization is complete. For large wounds, a second session of grafts is occasionally helpful to further expedite healing.

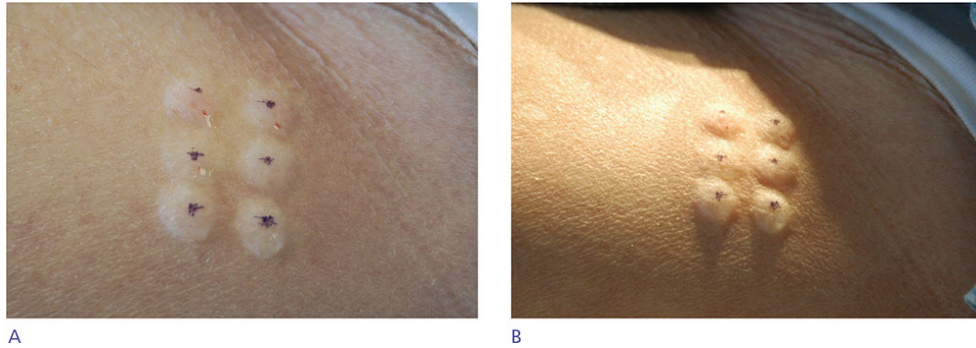


Figure 44-13. (A) Pinch graft donor site after superficial infiltration with local anesthesia. (B) Side lighting shows the swelling from local anesthesia which makes pinch graft harvesting simple.

Closure by tertiary intention (delayed primary closure)

Closure by tertiary intention is defined as the delay of primary closure beyond the date of defect creation. This approach may be considered in order to permit granulation tissue development in large or deep wounds, to monitor the wound for infection, or to permit additional recovery time for patients who cannot tolerate a closure procedure on the same day as excision. Other scenarios in which tertiary intention healing is performed are when a patient proves to be unable to adequately care for a second intention wound, changes their mind regarding planned second intention healing, or experiences complications such as infection or bleeding.

While linear closures and flaps may be executed by tertiary intention, delayed closure of scalp wounds is more typically performed with some form of grafting. FTSGs, with their increased metabolic requirement, may be more optimally placed on a granulating wound bed. Alternatively, a delayed STSG may be more suitable for a granulated wound so that the final result is not significantly depressed relative to the surrounding skin depression. Even STSGs, with their lower metabolic requirements, may not survive if substantial periosteum is absent in the wound base. Similarly, pinch grafts

delayed until after granulation tissue has formed may be more likely to survive and provide a more durable, healed wound.

Grafting in tertiary closures differs only in wound preparation. As peripheral reepithelialization may have occurred along with granulation tissue formation, and since there may be residual ointment and fibrin over the wound surface, it is important to appropriately prepare the wound bed for graft placement. When a complete closure using FTSG or STSG is planned, a thin rim of new epidermis should be excised from the wound margins, a technique referred to as “freshening the wound edges.” In addition, to ensure contact of the graft base with vascularized tissue, the surface of the granulation tissue should be gently disrupted. Typically this is performed with a very gentle curettage of the granulation tissue surface to remove residual ointment and fibrin. Some pinpoint bleeding will result and may be controlled with direct pressure. Graft placement may then take place in a standard fashion.

Linear Closure

When possible, linear closure is the preferred approach to wounds of the scalp, as such repairs are technically straightforward, heal rapidly, and are minimally traumatic to the patient. The scalp is occasionally so rigid and inflexible that linear closures may not be possible even with relatively small wounds. In some patients, subcentimeter defects can be difficult to approximate, while others have abundant laxity permitting much larger defects to be closed primarily. The relatively lax skin of the temporal scalp, lateral parietal scalp, and occipital scalp may facilitate closure, as can the removal of Burow triangles, which may otherwise impede wound edge approximation due to their inflexibility and mass.

As the galea is more difficult to tear than dermis with suture under normal circumstances, including a bite of galea when performing a sutured closure permits greater tension to be applied to the wound. In general, this requires that the depth of the defect be carried down through the galea to the periosteum, and undermining is performed in the avascular subgaleal plane. Unfortunately, the galea is, by its very nature, inflexible. Some have suggested scoring the galea from the subgaleal plane, typically at the lateral most extent of subgaleal undermining (galeotomy), or every 1 to 1.5 cm. This release of the galea can occasionally be useful in approximating wound

edges that could otherwise not be closed. However, this technique often provides little noticeable benefit, and studies have shown a demonstrably minimal benefit to galeotomy.⁵

Epidermal closure can be accomplished with layered suturing techniques, and pulley suture techniques may be helpful when closing defects under significant tension. On the scalp in particular, some surgeons favor the use of surgical staples which, when performed properly, induce only minimal tissue strangulation (Fig. 44-14).



Figure 44-14. Skin closure with surgical staples.

Flaps

The skin of the scalp is largely inelastic, particularly on the crown, though laterally, skin overlying muscles (superior frontalis, temporalis, and occipitalis) may be more flexible.⁶ Thus, there are two imperatives when considering a flap repair on the scalp. First, the surgeon must be able to estimate the intrinsic elasticity of the scalp in order to plan the successful execution of the flap. Second, the surgeon must understand the mechanisms of tissue movement for each flap type. For instance, advancement flaps and rotation flaps are largely dependent on intrinsic tissue elasticity, while V-Y (island pedicle) flaps are dependent on the flexibility of the underlying tissue that comprises the pedicle. In contrast, transposition flaps are less dependent on intrinsic elasticity, but are very dependent on the laxity of the donor site (Fig. 44-15).⁷ Although interpolation flaps have been described in hair restoration, they are rarely used for reconstruction. Free flaps are useful and frequently employed for reconstruction of large defects on the scalp, but are beyond the scope of this chapter.



Figure 44-15. (A) Large squamous cell carcinoma preoperatively. (B) After Mohs surgery. (C) Large bilobed flap sutured into place. (D) One month postoperatively.

Scalp reconstruction with flaps may permit hair-bearing skin to be transferred from the donor site to a previously hair-bearing defect (Fig. 44-16). The thick, inflexible, and inelastic characteristics associated with scalp skin make execution of flaps more challenging in this anatomic location, as flaps, by their nature, require a nearby donor site characterized by redundancy or laxity that can accommodate a loss of tissue.⁸

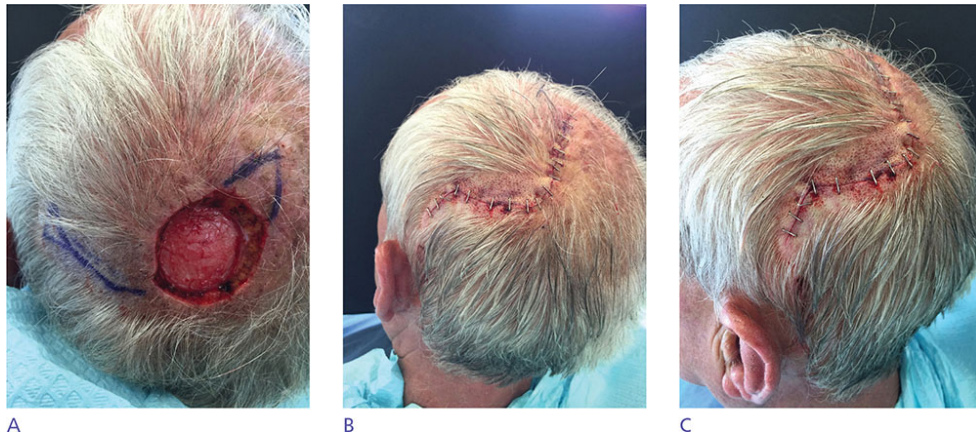


Figure 44-16. (A) Large Mohs defect on the vertex of the scalp. (B,C) Closure with rotation flap.

Therefore, scalp flaps may of necessity be larger or more involved (combining multiple flap types) than those performed in other areas.⁹ In planning the flap, an additional detail that must be considered in hair-bearing skin is the quantity and growth direction of hair within the flap and what its orientation will be once the flap is completed. For instance, when a defect is located on the lateral pate of a balding scalp and is adjacent to temporal or occipital scalp, the temporal or occipital skin may serve as an ample donor site. However, transfer of hair-bearing skin onto the bald scalp from a hair-bearing donor site may result in a highly conspicuous reconstruction. Furthermore, the orientation of the hair shafts may be incongruous with the surrounding hair adjacent to the wound.

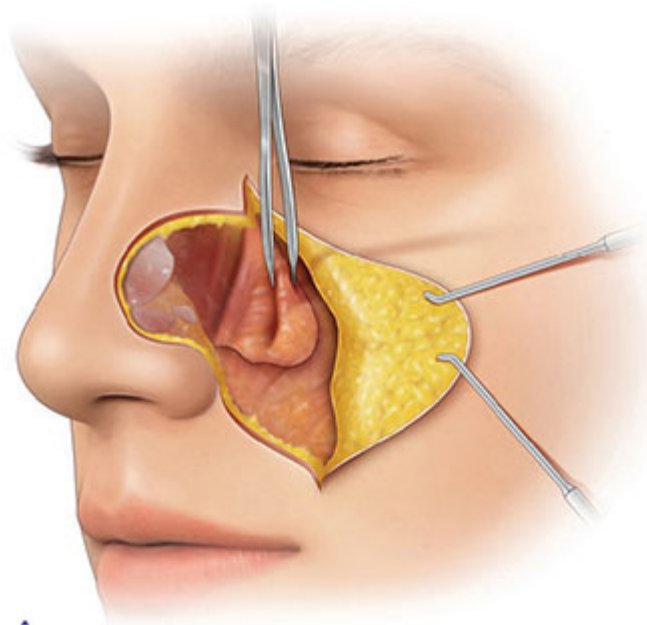
Galea is sometimes incorporated within the flap, though including the inelastic galea may tether the flap and restrict movement more than if it was not included. Still incorporating the galea provides a robust substrate into which sutures can be placed.

Occasionally, flap closures on the scalp are used to displace a defect to a more convenient or less aesthetically conspicuous location, leaving the nascent donor site open. The donor site can then be allowed to heal by

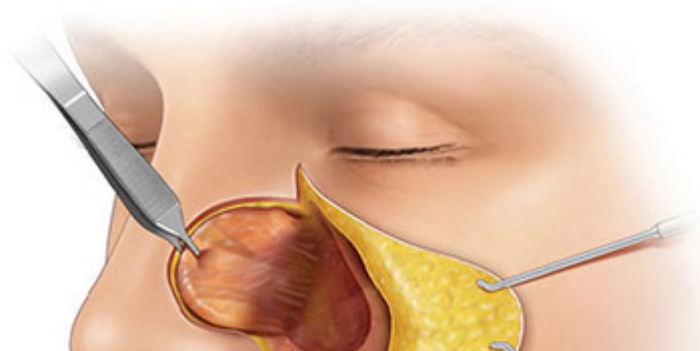
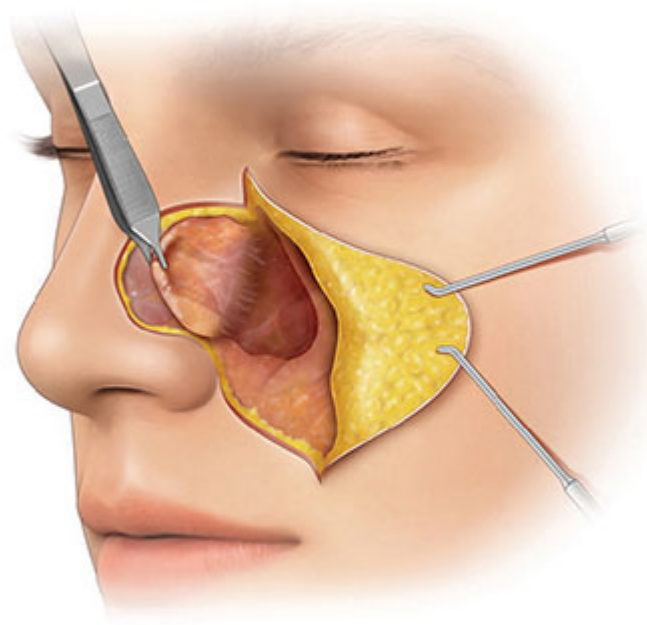
second intention using standard occlusive wound care, or be closed with a skin graft. This option is particularly useful when there is a dominant aesthetic need such as a defect toward the front of the scalp that can be displaced posteriorly or laterally to a more inconspicuous location.⁸

Fascial Flaps

Wounds that are devoid of periosteum and are too large to close primarily with a flap benefit from being resurfaced, at least in part, with a vascular covering. As previously discussed, chiseling the outer table of the bone can induce granulation, though reports of air emboli associated with this technique are of concern and serve as a motive to seek alternative approaches. Options frequently employed by dermatologic surgeons include hinge flaps (Fig. 44-17) and fascial transposition flaps (Fig. 44-18). The movement of adjacent fascia over the wound to cover, at least in part, the denuded bone provides a vascular source for granulation tissue and ultimately permits grafting, which is usually delayed as the vascularity of a newly placed fascial flap may not be sufficient to support the graft.



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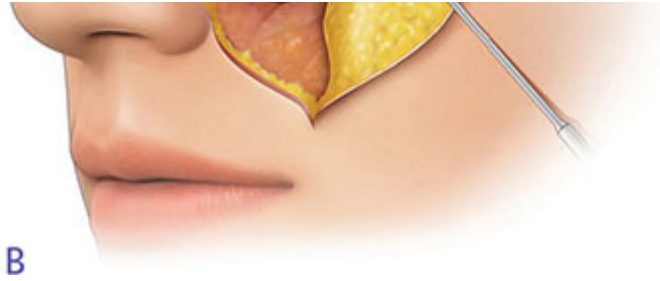


Figure 44-17. The hinge flap.

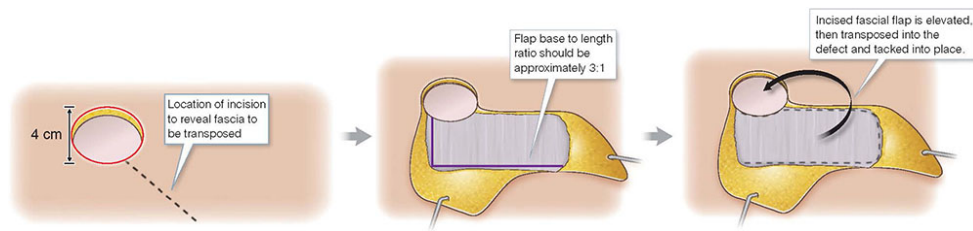


Figure 44-18. The fascial transposition flap.

The fascial transposition flap is essentially a banner flap where a rectangular flap is raised upon a vascularized base, elevated, and then transposed onto the wound base (Fig. 44-19). This flap may be harvested through incision and mobilization from the subgaleal approach; however it is generally easier to create access to the fascia by making an incision of the skin overlying the flap approximately perpendicular to the wound. The reflection of the skin from either side of this incision exposes the underlying fascia. By doing so, the fascia can be directly accessed, incised, and mobilized. The fascia is not very flexible or elastic, and the dimensions of the flap must accommodate these limitations. The wider the flap base, the more limited will be its mobility. A long and narrow flap is therefore preferred, in part due to the diminishing reach and pivotal restraint of the flap as it is transposed into the defect. The flap is then sutured into place with absorbable sutures and standard occlusive bandaging is performed and left in place for up to a week. Granulation tissue will begin forming over the flap shortly and ultimately provide a satisfactory vascular base suitable for delayed grafting or second intention wound healing.

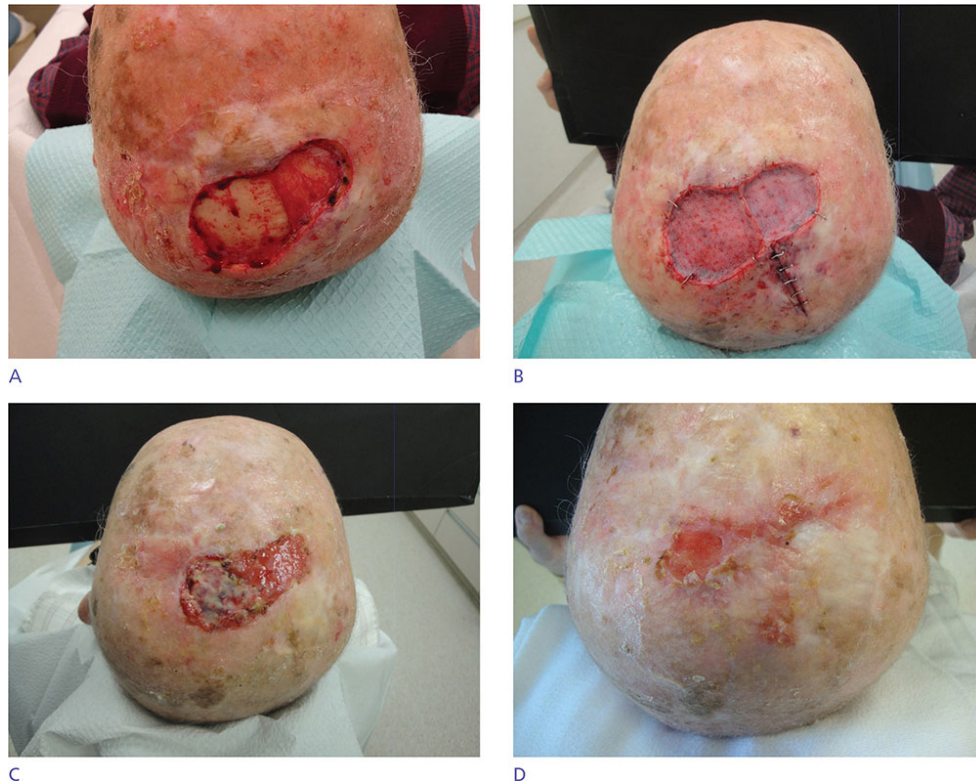


Figure 44-19. (A) Defect after Mohs excision of invasive squamous cell carcinoma. Defect extends to and includes periosteum for the left half of the defect. (B) Postoperative view after fascial transposition flap. Incisions perpendicular to the wound and reflection of the skin facilitated access to the fascial flap which is based at the left posterior portion of the wound. The flap and the right portion of the defect which did not extend through periosteum are covered with xenograft. (C) One-month postoperative healing by second intention. (D) Four months postoperatively.

SCALP WOUND CARE

Second intention wound management is a common and important option for scalp wounds. Overzealous wound care may lead to interference with the natural healing process or may be overly burdensome to the patient or their family. Occlusive wound care promotes rapid wound healing, especially when initiated immediately and continued for the first 24 to 48 hours, and augments the inflammatory phase of wound healing while speeding the transition to the proliferative phase of healing.¹⁰ Moist occlusion with an ointment base, covered by nonstick gauze dressing is preferred, and facilitates marginal reepithelialization. Consider the use of an antibiotic ointment if the wound is expected to take longer than 1 month to heal, though yeast colonization may occur which can be easily treated with twice-weekly

anticandidal topicals. After 2 or more weeks, hydrocolloid dressings such as DuoDerm may help to optimize hygiene while diminishing the frequency of dressing changes and the trauma associated with dressing removal on the newly reepithelializing wound. Hydrocolloid dressings can remain in place for up to 1 week. Permitting warm tap water to flow over the wound is a gentle way to clean and débride the wound bed.

DELAYED WOUND HEALING OF THE SCALP

Normal wound healing progresses at varying rates depending on the nature of the wound and the host, and there is generally measurable progress from week to week. When the progress of healing cannot be measured over a 2-week period, it should alert the physician that there may be reasons for concern. If this failure to progress can be documented over a period of a month, then active intervention is indicated ([Table 44-6](#)).

Table 44-6. Reasons for Failure to Heal

Problem	Solution
Overzealous wound care	↓ Wound care; hydrocolloid after cleansing solution/tertiary closure
Host factors	Address medical factor
Persistence of tumor	Biopsy to rule out malignancy
Bacterial colonization	Topical antibiotics for wound >1 month Culture and prescribe antibiotic
Candida infection	Topical antiyeast (clotrimazole) Consider prophylactic. Topical antibiotics for wound >1 month. Culture and prescribe antibiotic
Hypergranulation	Suspend occlusive wound care Topical class I steroids
Unstable skin, failure to progress	Two-week course with class I steroid topically

Poor adherence to wound care instructions, misunderstanding the instructions, or deviation from recommended wound care are frequent reasons for delayed healing. When this is suspected, careful reiteration of appropriate wound care may correct the problem. When feasible, changing to hydrocolloid wound dressings may be helpful, as it drops the responsibility from the patient and their family in caring for the wound to weekly bandage changes.

When all infectious causes of failure to heal and problems with wound care are ruled out, it may be necessary to rebiopsy the wound to exclude the possibility of residual tumor. Residual basal cell carcinoma, in particular, can result in failure to heal without overt evidence of the tumor itself. Multiple biopsies may be needed to identify the presence of residual tumor.

When all other causes for nonhealing have been ruled out, and when ample granulation tissue has formed, a course of high-potency topical steroids should be considered. This clinical situation is usually characterized by a failure to heal over a period greater than 2 months with a failure to progress and perhaps even regression of wound healing. When this approach is effective, it will be evident within 2 weeks, and therefore the treatment course is limited. When there is a positive response, occlusive wound care is resumed thereafter. It may be necessary for additional courses of topical steroid to completely heal the wound and maintain it. While there are times when the rapidity of healing is remarkable, with large areas of epithelialization occurring over a 2-week period, this skin may remain fragile, and so careful instructions are given to continue occlusive wound care until completely healed. Even after complete healing, continued application of ointment for several months may help and protect the newly healed skin, protecting it from mechanical injury.

This process should be distinguished from erosive pustular dermatosis, which can occasionally complicate wound healing on the scalp. This condition tends to be more chronic, and patients may benefit from gentle soaking and washing followed by the application of high-potency topical steroids (Table 44-7).

Table 44-7. Enhanced Hygiene for Erosive Pustular Dermatitis

Physician Directed

- Daily application of class I topical steroid (up to 2 weeks)
- Step down class IV–V steroid (as needed)

Patient Directed

- Twice-daily warm H₂O₂ dressings (wash cloth) × 15 minutes
- 30-second GENTLE, circular agitation of wash cloth at conclusion of wet dressing
- Application of topical medicines (daily or as directed)
- Daily or frequent shampoo with nontoxic shampoo
 - Fingertip massage of scalp while shampooing

Maintenance

- All of the above except medicines
- Wet dressings 2–7 times weekly
- Continue frequent shampoo and fingertip massage
- Continue moisturization

Benefits of complete tumor extirpation in the suprafollicular plane

There is a tendency for cutaneous malignancies to extend down the root sheath of hair follicles, and thus standard scalp excisions extend deep to the hair follicle. In contrast, with Mohs micrographic surgery, it is possible to excise superficial malignancies at a depth above the hair follicle. There are several benefits to keeping scalp excisions in a relatively superficial plane when possible. First, superficial wounds tend to heal well by second intention. Second, wound healing can be relatively rapid due to reepithelialization from the still-present follicular epithelium, which may markedly enhance the speed of healing in healthy scalp skin. Third, when tumor removal is performed from hair-bearing skin, viable hair follicles may regrow hair and completely camouflage the scar. The technique of suprafollicular tumor excision is inadvisable when a baseline elevated risk of recurrence or the complexity of tumor removal makes follicular

preservation unreasonable, and it would be contraindicated for melanoma or tumors of dermal origin.

Pearls on addressing scalp immobility

When Mohs surgery is performed and there is a period of time between excision and closure, it is very helpful to assess the wound prior to local anesthesia infiltration while planning reconstruction. Preoperative planning does not mitigate the fact that the scalp may become turgid after injection of anesthesia. There are several tactics at the time of closure that can facilitate intraoperative tissue manipulation by improving tissue mobility (Table 44-8). First, delaying reconstruction for 15 to 30 minutes after the site is anesthetized may be helpful, and compression of the skin at the operative site may evacuate some of the anesthesia volume out of the tissue while not appreciably affecting the efficacy of the anesthesia itself. Even manual compression by the surgeon or nurse for a few minutes just prior to initiating the surgery may make a difference.

Table 44-8. Managing Scalp Immobility

Preoperative and preanesthesia assessment
Delay closure for 20–30 minutes after anesthesia
Apply compression to the skin—external device or manual compression
Presuture under tension
Local anesthesia with a ring block
■ Local anesthesia with long-acting product (e.g., bupivacaine)

Another helpful approach is performing a ring block, rather than direct infiltration of the flap skin itself. Here, infiltration must be carried out at all levels, including dermis and the deep subcutaneous tissue, in order to effectively block the entire area. Similarly, when wounds are within skin, innervated exclusively by the supraorbital or supratrochlear nerves, a nerve block of the forehead anywhere from the brow to the hairline may achieve anesthesia without reducing the mobility of the scalp skin.

Some mild tissue creep may be seen by presuturing the area (in the case of Mohs, this may be performed between stages), though the clinical impact of this approach is not well defined, and cadaveric studies have suggested that minimal acute expansion occurs in scalp wounds.

Another useful tactic is to use a long-acting local anesthetic such as bupivacaine that may induce anesthesia for several hours after the initial injection. If this is done at the time of Mohs surgery, it may obviate the need for large volumes of anesthesia just prior to reconstruction.

Aesthetic Considerations

As noted above, many patients do not have high aesthetic expectations regarding their scalp appearance, though this is quite variable and should always be discussed during the preoperative consultation. On the scalp, dog-ears often resolve spontaneously.^{11–13} Conversely, concavities may not resolve, and although they may not be highly noticeable, they should be avoided when possible. This is one of the benefits of tertiary closure, as granulation tissue may help provide bulk to a planned graft site.

Reconstructing hairlines, when they exist, is perhaps the most important aesthetic consideration in reconstruction of the scalp. Therefore, when it is possible to reestablish the hairline, more aggressive consideration of flap closure should be made (Fig. 44-20). Rotation flaps incised along the frontal hairline may reestablish the continuity of the hairline, and is an excellent strategy to be considered even if a very large flap is required. Typically, this flap results in favorably oriented hair follicles and a natural looking hairline.



Figure 44-20. (A) Basal cell carcinoma on the frontal scalp. (B) Post Mohs defect. (C) Rotation flap planned for preservation of the frontal hairline. (D) Following execution of rotation flap.

CONCLUSIONS

Reconstruction of the scalp involves several unique considerations, as the lack of tissue elasticity in this location can make reconstruction of even modestly sized defects challenging. While dermatologic surgeons frequently eschew the use of grafts in lieu of local flaps, the scalp is an important exception to this general rule. Similarly, healing by secondary and tertiary intention, while always options in dermatologic surgery, are more often utilized on scalp defects. Still, linear closure, when feasible, remains the first-line approach, when possible, for scalp defects.

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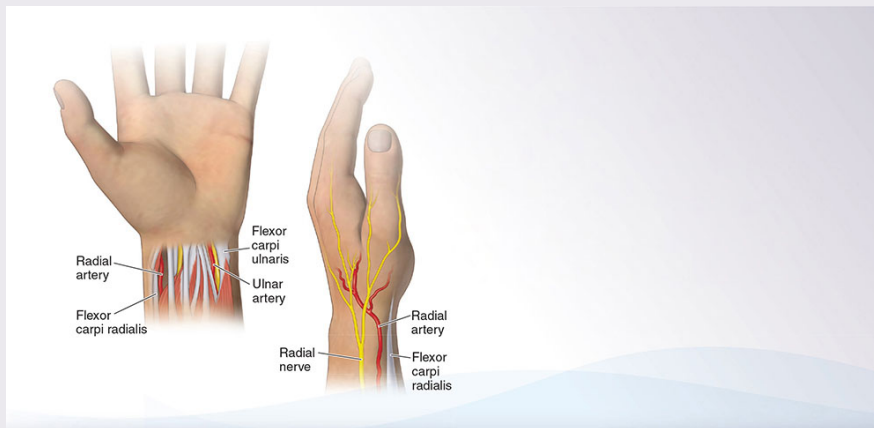
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CHAPTER 45 Reconstruction of the Hands and Feet

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SUMMARY

- A thorough appreciation of anatomy is a prerequisite prior to engaging in any surgery on the hand and foot.
- Functional considerations play an important role in closure design.

- Closure options run the gamut from secondary intention healing to cross-finger flaps.

Beginner Tips



- Assess laxity and tension by having the patient make a fist and move through a range of motion.
- The atrophic dermis on the dorsal hand lends itself to percutaneous suturing techniques.
- Residual edema is possible, particularly if lymphatics are severed.

Expert Tips



- Random pattern flaps are most useful on the proximal hand and fingers.
- Fasciocutaneous flaps such as the keystone flap may help preserve vascular supply, but require a high level of knowledge and comfort with local anatomy to be properly freed and undermined.

Don't Forget!



- Nerve blocks are very useful on the hand and foot, as minimizing local anesthetic infiltration may reduce background edema and mitigate against anatomic distortion.
- Do not aggressively undermine fasciocutaneous flaps, as this may lead to impaired blood supply.

Pitfalls and Cautions



- Both motor and sensory nerve damage may occur with large hand and foot repairs.
- Grafts should be adequately immobilized to maximize their chance of survival.

Patient Education Points



- Minimizing tension across a healing surgical site is critical; splints may help not simply by immobilizing the relevant anatomy, but by reminding the

patient of the need to minimize activity. Assess patient compliance and motivation *before* considering a two-stage flap.

- For foot reconstruction, the legs should be elevated as much as possible in the postoperative period.

Billing Pearls



- Fasciocutaneous flaps should be coded using the adjacent tissue transfer codes (14040–14041).
- A cross-finger flap is coded as 15574, and division is coded as 15620.
- When repairing a fingertip defect with a cross-finger flap, both flap and graft CPT codes may be used.

CHAPTER 45 Reconstruction of the Hands and Feet

INTRODUCTION

The hand represents a unique challenge for any surgeon, with numerous important vascular, neurologic, and cutaneous structures residing within close proximity. Reconstruction of this area is predicated on a thorough appreciation of local anatomy, as well as an established comfort level with local anesthesia and nerve blocks.

HAND ANATOMY

The use of appropriate nomenclature facilitates communication between clinicians. Anterior and posterior surfaces are described as palmar and dorsal, respectively. For laterality, radial and ulnar are preferred over medial and lateral. The fingers are numbered from radial to ulnar, but common names are favored. Each phalanx is numbered from distal to proximal in numerical order. The osseous structure of the hand consists of 8 carpal bones, 5 metacarpals, and 14 phalanges.

Vascular anatomy

The vascular supply to the hand comes from the radial and ulnar arteries. The radial artery enters the hand after traveling between the brachioradialis and flexor carpi radialis on the volar wrist. The artery then traverses the

anatomic snuffbox where it gives off the superficial palmar branch, providing a contribution to the superficial arch. The artery then passes through the first dorsal interosseous muscle where it forms the deep palmar arch.

The ulnar artery provides the other primary contribution to the blood supply of the hand. After traveling under the flexor carpi ulnaris tendon, the artery enters the hand through Guyon's canal alongside the ulnar nerve, where it becomes the superficial arch. The superficial arch can be approximated by identifying Kaplan's cardinal line, which is drawn by abducting the thumb and drawing a line following its ulnar border. The deep arch is located 1 cm proximal to the superficial arch (Fig. 45-1).

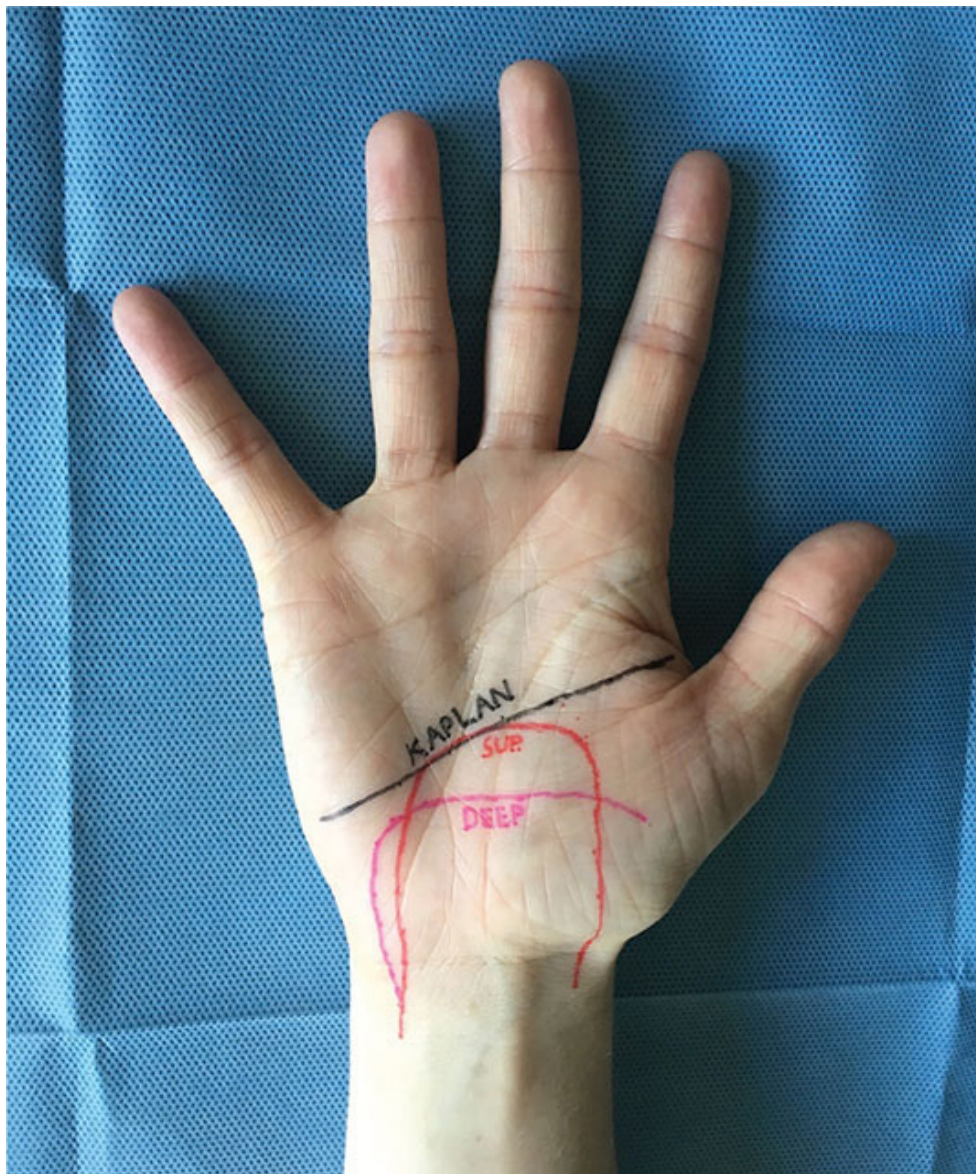


Figure 45-1. Kaplan's cardinal line can help locate the superficial palmar arch. The deep palmar arch is present 1 cm proximal.

Vascularity to most fingers and the thumb arises from the deep arch. A common digital artery extends to each digit, bifurcating into radial and ulnar branches. One exception to this is the vascular supply to the ulnar border of the small finger, which arises from the superficial arch.

The relationship between the digital arteries and nerves also changes in the finger ([Fig. 45-2](#)). In the hand, the digital artery lies palmar to the nerve and this relationship switches in the finger, with the artery lying dorsal to the digital nerve.



Figure 45-2. The relationship between the digital arteries and nerves changes in the finger.

Muscles and tendons

The muscles of the hand and wrist are divided into two broad categories, the extrinsic and intrinsic systems. The extrinsic system consists of tendons with muscle bellies that lie outside of the hand.

Extrinsic muscles

The extrinsic extensor system of the hand consists of nine muscles separated into six compartments. These muscles are all innervated by the radial nerve proper, or its branch, the posterior interosseous nerve ([Table 45-1](#)).

Table 45-1. Muscles of the Hand

Compartment	Muscle	Function
1st Compartment	■ Extensor pollicis brevis	■ Thumb extension
	■ Abductor pollicis longus	■ Thumb abduction
2nd Compartment	■ Extensor carpi radialis longus	■ Wrist extension and radial deviation
	■ Extensor carpi radialis brevis	■ Wrist extension and radial deviation
3rd Compartment	■ Extensor pollicis longus	■ Thumb extension
4th Compartment	■ Extensor indicis proprius	■ Index finger extension
	■ Extensor digitorum communis	■ Extension of the hand, wrist, and fingers
5th Compartment	■ Extensor digiti minimi	■ Small finger extension
6th Compartment	■ Extensor carpi ulnaris	■ Wrist extension and ulnar deviation

The extrinsic flexor system consists of six muscles. Wrist flexors include the flexor carpi radialis, palmaris longus, and flexor carpi ulnaris. The extrinsic finger flexors include the flexor digitorum profundus, flexor digitorum superficialis, and flexor pollicis longus. The innervation for the flexors is provided by the median nerve, except for the flexor carpi ulnaris and flexor digitorum profundus muscles to the ring and small finger, which are innervated by the ulnar nerve.

Intrinsic muscles

The intrinsic muscles of the hand are defined as those with muscle bellies arising within the hand. These muscles may be categorized into three main groups: thenar, hypothenar, and interosseous.

The thenar muscles include the abductor pollicis brevis, flexor pollicis brevis, and opponens pollicis. The muscles are all innervated by the median nerve, with the deep portion of the abductor pollicis being innervated by the ulnar nerve. Deep to the thenar muscles lies the adductor pollicis, innervated by the ulnar nerve.

The hypothenar muscles are the abductor digiti minimi, flexor digiti minimi, and opponens digiti minimi, innervated by the motor branch of the ulnar nerve.

Three muscles comprise the interosseous group in the hand. The dorsal interosseous muscles allow for abduction of the fingers away from the long finger. The palmar interosseous muscles cause adduction of the fingers. The lumbrical muscles originate from the radial side of the flexor digitorum profundus tendons. They function to flex the fingers at the metacarpal phalangeal joints and extend the interphalangeal joints. The interosseous muscles are innervated by the motor branch of the ulnar nerve, with the exception of the lumbricals. The innervation for the lumbricals corresponds to the innervation of their corresponding flexor digitorum muscle, with the radial two lumbricals being innervated by the median nerve and the ulnar lumbricals with ulnar nerve innervation.

Hand innervation

The median, ulnar, and radial nerves supply sensation and neurologic function to the hand.

The radial nerve divides in the forearm into its two main divisions, the posterior interosseous nerve and radial sensory nerve. The radial sensory nerve travels under the brachioradialis, eventually piercing the forearm fascia 8 cm proximal to the radial styloid. From there it courses over the anatomic snuffbox before dividing into medial and lateral branches. The nerve is very superficial and can be injured with dissection deep to the skin. It provides sensation to the dorsum of the thumb, the dorsum of the index finger to the level of the middle phalanx, and to the ulnar half of the long finger to the level of the middle phalanx.

The median nerve provides major sensory and minor motor innervation to the hand. It enters the hand after giving off the palmar cutaneous branch in the forearm, where it provides sensation to the lateral aspect of the palm. The

median nerve enters the hand after traveling under the transverse carpal ligament. The nerve branches into several different components at this point. The recurrent branch of the motor nerve provides motor innervation to the thenar muscles and to part of the flexor pollicis brevis. The common palmar digital branch and proper palmar digital branches provide sensation to the radial three and a half digits on the palmar side and to the dorsal tips of the index, middle finger, and thumb.

The ulnar nerve enters the hand after passing superficial to the transverse carpal ligament on the ulnar aspect of the wrist. It bifurcates into a sensory and deep motor component in Guyon's canal. The motor branch provides innervation to the interossei muscles, the hypothenar muscles, and the third and fourth lumbricals. The sensory branch divides into dorsal and palmar components, providing sensation to the small finger and half of the ring finger.

ANESTHESIA

Anesthetics

Numerous medication options exist for use of local anesthesia. The use of local anesthetics combined with epinephrine has been proven to be safe and effective, providing improved hemostasis and longer duration of anesthesia.¹ In the past, classical surgical teaching dictated that epinephrine was to be avoided in the digits due to risk of digital necrosis. These cases were largely presented in case reports and with the use of nonstandard anesthetic formulations. Numerous large studies have demonstrated the safe use of epinephrine in the hand and fingers.^{2,3} Nonetheless the risk of mechanical tourniquet caused by anesthetic infiltration should be acknowledged.

Few absolute contraindications exist for the use of the local anesthetic and blocks. Anesthetics do not work well in an acidic environment, reducing their efficacy in cases of infection. Additionally, these blocks can be uncomfortable when placed, making their use in young and uncooperative patients difficult. Caution should also be used in cases of compromised circulation.

A smaller gauge needle (30 gauge) is routinely used in the hand due to the high density of pain fibers. When injecting with small caliber needles, the

use of lower-volume syringes (3 mL) decreases the amount of force needed to administer the injection.

Local block

The simplest method to introduce anesthesia is with local anesthesia administered in the subcutaneous tissue. This method tends to be safe, effective, and rapid. Limitations include the inability to anesthetize a large area and inadequate anesthesia. Additionally, the infiltrated anesthetic may affect tissue-handling characteristics and alter normal tissue planes. A 30-gauge needle is used to infiltrate the anesthetic in the subcutaneous plane. A palpable increase in skin turgor is achieved with proper injection technique.

Wrist blocks

Wrist blocks provide anesthesia to the entire hand. The benefit of a wrist block lies in the ease of its administration, as well as preservation of the extrinsic function of the hand. With proper technique a wide area can be rapidly anesthetized with a few injections. Isolated portions of this block can be used as needed.

The three nerves that provide sensation to the hand are blocked individually. Surface landmarks provide guides to where the injections need to be placed in order to localize the nerves. The median nerve is blocked as it passes between the palmaris longus and flexor carpi radialis tendon. In order to find this interval, the patient is instructed to touch the thumb and ring fingers and flex the wrist ([Fig. 45-3](#)). This motion brings the palmaris longus and flexor carpi radialis tendons taut against the skin. In patients without a palmaris longus, the injection is given immediately ulnar to the flexor carpi radialis tendon. A 25-gauge 1½-in needle is used to infiltrate 3 to 6 mL of anesthetic at the level of the proximal wrist crease. The needle can often be felt piercing the transverse carpal ligament, indicating proper positioning. Effort should be made to inject 1 to 2 mL of anesthetic as the needle is withdrawn to numb the palmar cutaneous nerve.



Figure 45-3. The flexor carpi radialis and palmaris longus are visible with wrist flexion. The site for injection is indicated by the *arrow*.

The ulnar nerve is blocked at the level of the wrist as it courses near the flexor carpi ulnaris tendon. The tendon can be identified by having the patient flex and deviate the wrist to the ulnar side. Local anesthetic is placed ulnar to the flexor carpi ulnaris tendon (Fig. 45-4). Placement of the injection ulnar to the tendon minimizes the risk of intravascular injection in the ulnar artery, which runs radial to the ulnar nerve. The intrinsic musculature of the hand

will be affected, as this block is given proximal to the motor branch of the ulnar nerve.

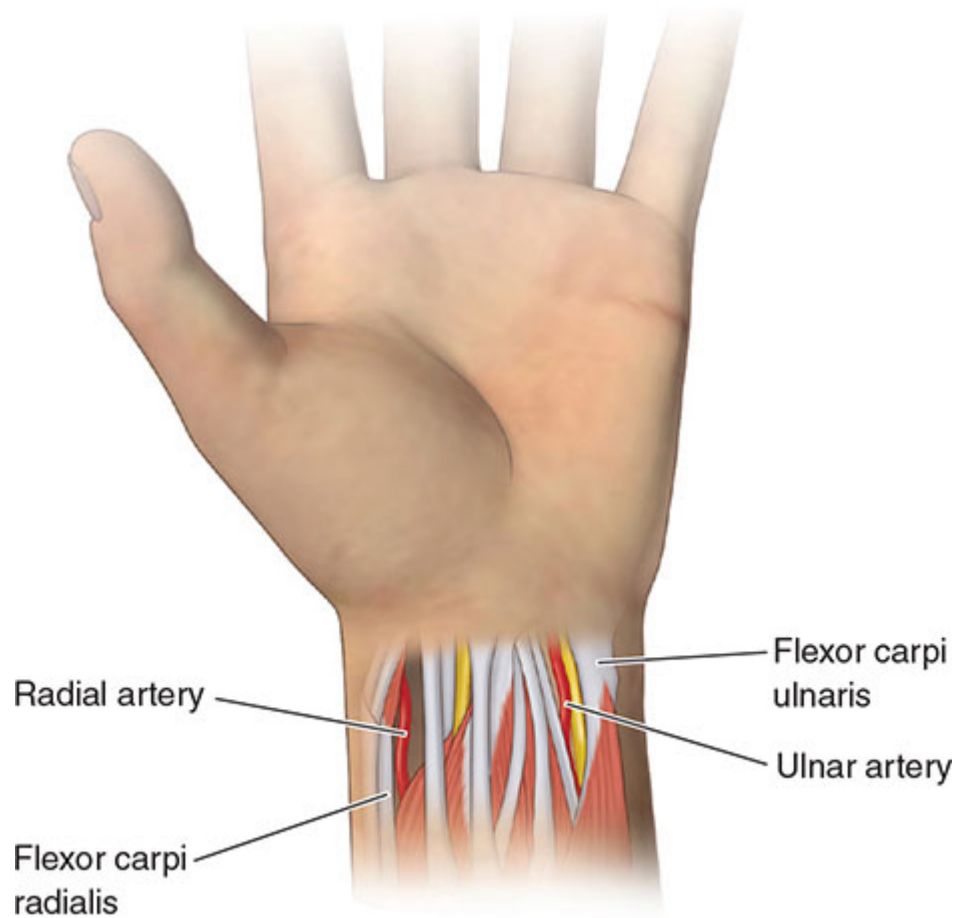


Figure 45-4. Relationship of the ulnar nerve and the flexor carpi ulnaris and flexor carpi radialis tendons. Local anesthetic is placed ulnar to the flexor carpi ulnaris tendon.

Radial nerve anesthesia is obtained by infiltrating local anesthesia in a field block about the radial styloid. Due to the numerous branches of the superficial radial nerve, a larger area needs to be covered. Local anesthetic is injected subcutaneously around the styloid (Fig. 45-5). Typically 8 to 10 mL of local anesthetic is utilized (Fig. 45-6).^{4,5}

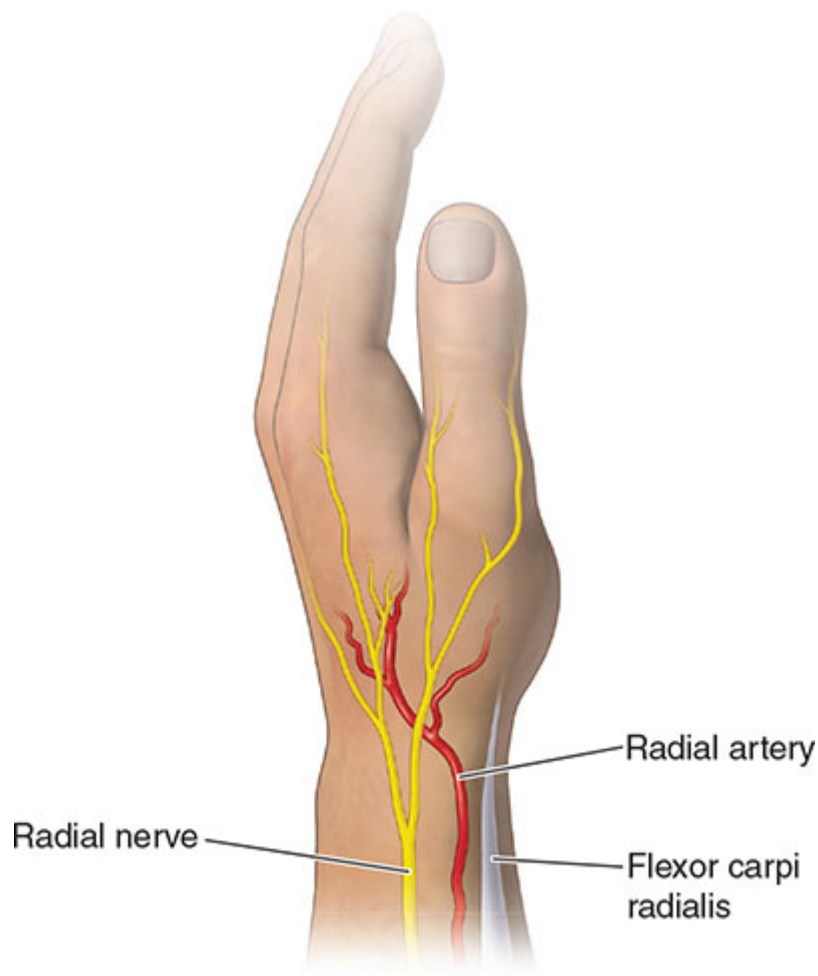


Figure 45-5. Relationship of the radial nerve, the radial artery, and the flexor carpi radialis tendon. Radial nerve anesthesia is obtained by infiltrating local anesthesia in a field block about the radial styloid.

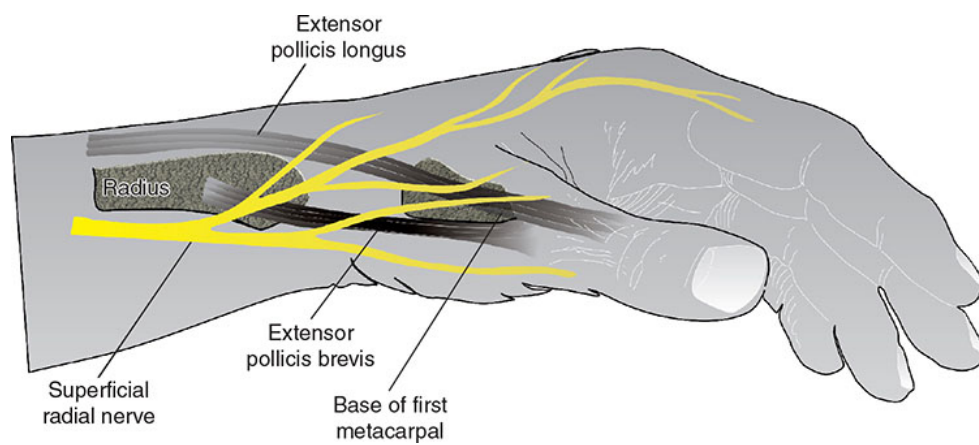


Figure 45-6. Common arrangement of superficial branches of the radial nerve.

Digital blocks

A number of techniques exist to provide anesthesia to the digits. Transthecal injection can provide rapid anesthesia. The flexor tendon is identified around the distal palmar crease of the finger. A 25-gauge needle is placed through the flexor tendon to the level of the bone. The needle is then withdrawn slightly in order to allow infiltration of the anesthetic. Approximately 2 mL is infused, and anesthesia of the entire finger is obtained.⁶

Transmetacarpal injection is another common practice. The anesthetic is infused on both sides of the metacarpal at the level of the distal palmar crease. A volar or dorsal approach can be utilized, though dorsal injections tend to be better tolerated, and 2 mL of anesthetic is injected on each side of the metacarpal neck. Alternatively, a ½-in needle can be placed in the web space between the fingers. The needle is fully seated and 2 mL of anesthetic is injected. Anesthesia of the entire digit is obtained.

Subcutaneous block of the finger is performed through a series of dorsal injections. An injection is placed at the level of the web space of the finger. The needle is placed through the skin to the volar aspect of the finger. 1 mL of anesthetic is injected on the palmar aspect of the finger and, as the needle is withdrawn, an additional 1 mL of anesthetic is infused in order to address the dorsal sensory branch of the finger. The process is repeated on the other side of the finger.⁷

FOOT ANATOMY

The foot contains 20 bones of varying shape and function. Beginning proximally, the hindfoot consists of the calcaneus and talus followed by the midfoot containing the navicular, cuboid, and cuneiforms and finally the forefoot consisting of the metatarsals and phalanges.

The use of proper nomenclature regarding the foot is vital for proper documentation and communication. The top and bottom portions of the foot are termed dorsal and plantar, respectively. The proximal to distal portions of the foot are named based on the underlying bony anatomy: hindfoot, midfoot, and forefoot.

Foot vasculature

The vascular supply to the foot is provided by three arteries (Fig. 45-7). The peroneal artery is a branch arising from the posterior tibial artery. In its course to the foot it travels through the interosseous membrane and travels along the lateral aspect of the foot, branching into the posterior lateral malleolar artery and a communicating branch before terminating as the lateral calcaneal branch.

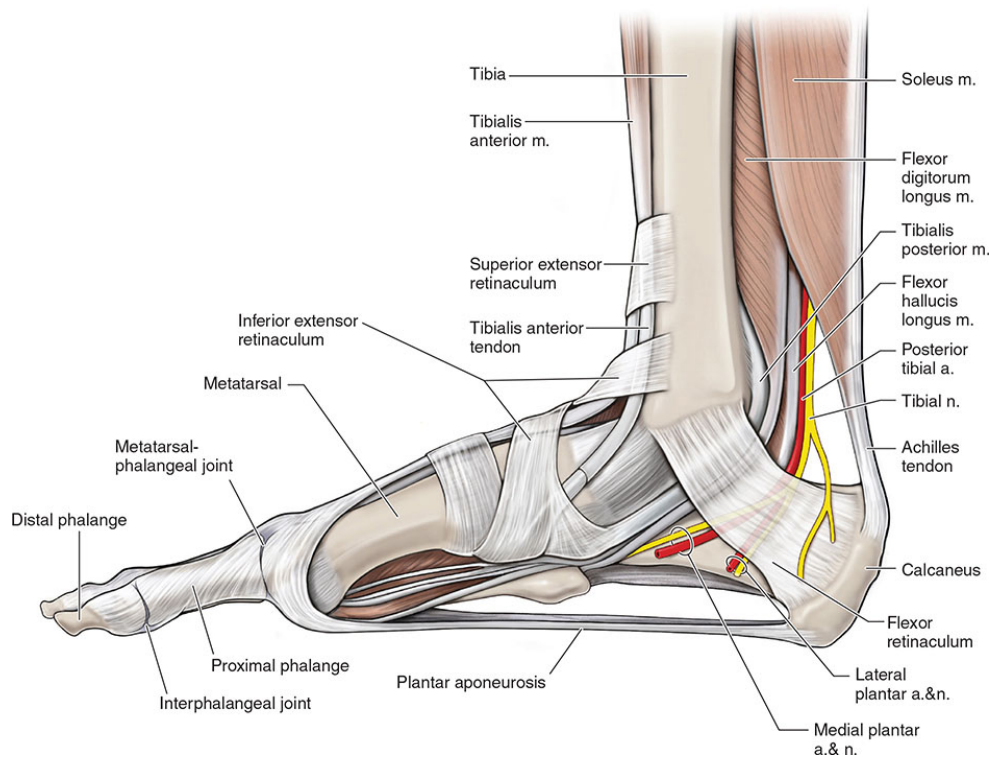


Figure 45-7. Medial view of the fascia of the right foot.

The posterior tibial artery arises from the popliteal artery. It travels within the posterior compartment of the lower leg, eventually passing behind the medial malleolus. At the ankle the posterior tibial artery has three branches, the posterior medial malleolar artery, communicating branch, and artery of the tarsal canal. Once in the foot it terminates in two branches, the lateral plantar and medial plantar arteries, providing blood supply to the plantar aspect of the foot.

The anterior tibial artery is the other terminal branch of the popliteal artery. After branching from the popliteal artery it pierces the intermuscular

septum and becomes superficial at the level of ankle, where it becomes the dorsalis pedis artery. Three branches arise from the dorsalis pedis distal to the ankle: the arcuate, lateral, and medial tarsal arteries. These branches are responsible for blood supply of the dorsal foot.

The toes and distal aspect of the foot obtain their perfusion from branches arising from the plantar arch. The plantar arch is the result of an anastomosis between the lateral plantar artery and dorsalis pedis.

Muscles and tendons of the foot

As with the hand, the muscles of the foot can be broadly categorized into two groups, the extrinsic and intrinsic muscles.

The extrinsic muscles of the foot can be further divided into three groups: anterior, posterior, and peroneal. The anterior group consists of the tibialis anterior that is responsible for ankle dorsiflexion, the extensor hallucis longus for great toe extension, and the extensor digitorum longus for lesser toe extension. The deep peroneal nerve innervates these muscles.

The posterior group consists of the superficial layer and deep layer. The superficial layer consists of the plantaris, soleus, and gastrocnemius. These muscles combine to form the Achilles tendon, providing plantar flexion. The deep group muscles are the tibialis posterior and flexor hallucis longus. The tibialis posterior provides plantar flexion and inversion. The flexor hallucis longus causes flexion of the great toe. Innervation for this group is provided by tibial nerve.

The final extrinsic group is the peroneal group. The peroneus longus and brevis both insert on the lateral portion of the foot and provide foot pronation and plantar flexion.

The intrinsic musculature of the foot is often described as being in layers. The first, or superficial, layer contains the abductor hallucis, flexor digitorum brevis, and abductor digiti minimi. The second layer consists of the lumbricals and quadratus plantae. The third layer of muscles includes the adductor hallucis, flexor hallucis brevis, and flexor digiti minimi. Finally the fourth layer is made up of the plantar and dorsal interossei. These muscles control motion in the forefoot.

Foot innervation

Five nerves provide sensation to the foot. The common peroneal nerve divides into two branches around the fibular head, the deep and superficial peroneal nerves. In addition to their muscular innervations, the deep peroneal nerve provides sensation to the first dorsal web space of the foot and the superficial peroneal nerve provides sensation to the remaining dorsum of the foot. The medial and lateral plantar nerves are branches of the tibial nerve and provide sensation to the plantar aspect of the foot. The medial plantar nerve innervates the great, second, and part of the third toe with the lateral plantar nerve supplying the remainder of the toes. Finally the sural nerve provides cutaneous sensation to the lateral aspect of the dorsal foot.

FOOT ANESTHESIA

Most general principles for providing anesthesia for the hand hold true for the foot. Large observational studies have demonstrated the safety of epinephrine in the foot and toes without increased risks of gangrene or ischemic injury.⁸

Local block

Local block represents the simplest method of providing an area of local anesthesia. Local anesthetic is injected into the skin and subcutaneous tissues to provide rapid and safe anesthesia. A small 27- to 30-gauge needle is typically used.

Ankle block

An ankle block requires the administration of anesthetic to five different nerves, and provides anesthesia to the entire ankle and foot (Fig. 45-8). Selective nerves can be blocked depending on the area where surgery is planned.⁹

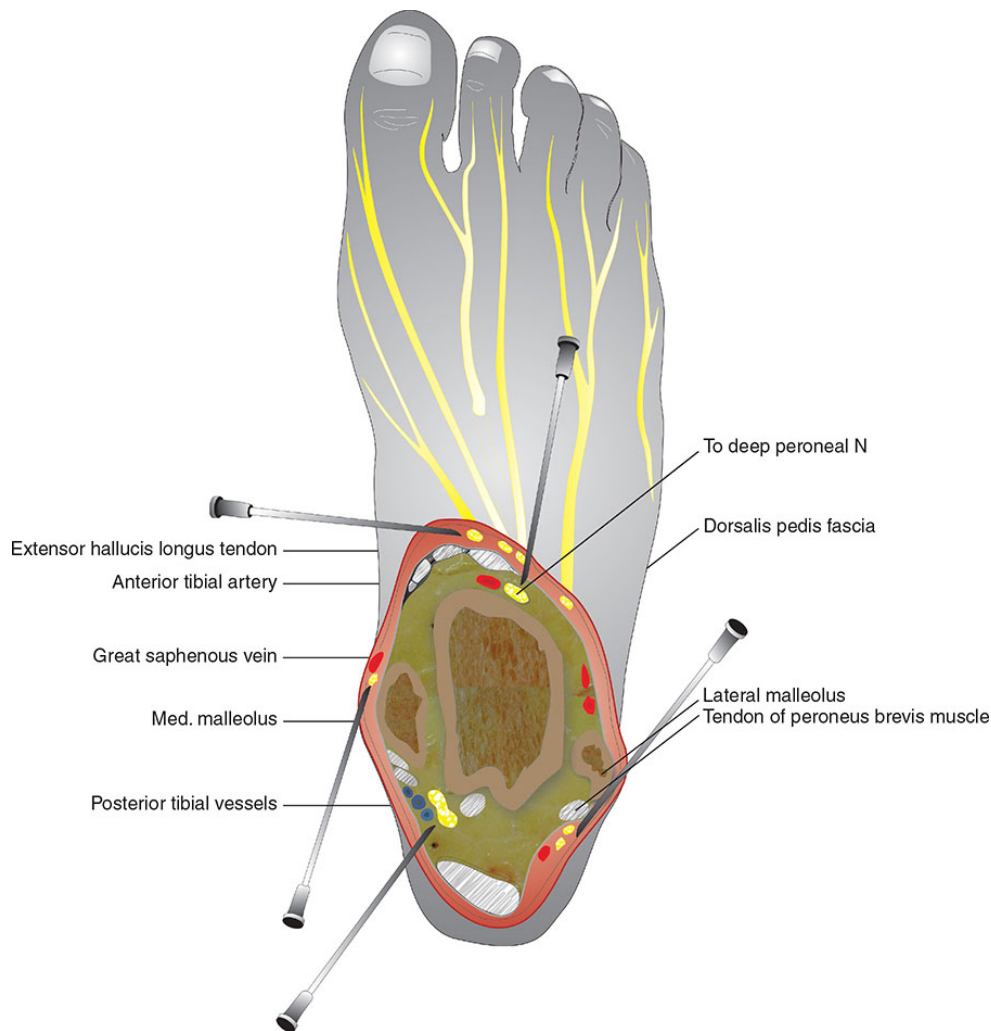


Figure 45-8. Innervation of the ankle joint and foot.

The deep peroneal nerve is identified by drawing a line between the two malleoli. The tendons of the extensor hallucis longus and extensor digitorum longus are identified having the patient extend their toes. The anterior tibial artery is identified by palpation between these tendons. A skin wheal is injected superficially. The needle is then advanced more deeply through the extensor retinaculum where 3 to 5 mL of anesthetic is injected. The superficial peroneal nerve is blocked through the same entry point, but the needle is directed toward the lateral malleolus. Three to 5 mL of anesthetic is injected. Blockade of these two nerves provides anesthesia for the dorsum of the foot.

The plantar aspect of the foot is addressed via blockade of the posterior tibial nerve. The posterior tibial artery is first identified behind the medial

malleolus. The needle is inserted posterolateral to the artery and slowly advanced. If paresthesias are elicited, the needle is slightly withdrawn. Seven to 10 mL of local anesthetic is injected as the needle is withdrawn.

The sural nerve needs to be identified to anesthetize the lateral aspect of the foot. It is identified by locating the areal between the lateral malleolus and Achilles tendon. The needle is inserted superficially, lateral to the tendon, and directed toward the lateral malleolus. 5 to 10 mL of local anesthetic is injected.^{10–12}

Digital block of the toes

Digital block of the toes is done by blocking the digital nerves as they run between the metatarsal heads. A small skin wheal is placed between the metatarsal heads on the dorsum of the foot. The needle is advanced while injecting anesthetic parallel to the metatarsal bone. Care is taken to avoid penetrating the sole of the foot. The nerves are located deep to the metatarsal heads, closer to the plantar than dorsal aspect of the foot. Three to 5 mL of anesthetic is injected, and the process is repeated on the other side of the involved toe.¹³

SPECIAL CONSIDERATIONS FOR SOFT-TISSUE TUMORS OF THE HANDS AND FEET

Soft-tissue tumors of the hands and feet may arise from both skin and subcutaneous anatomic structures including tendons, nerves, and blood vessels. While the same tumors often occur elsewhere on the body, the hand's anatomy and function present unique considerations when approaching surgical excision and reconstruction.

Malignant tumors of the hands and feet

Squamous cell carcinoma

Squamous cell carcinoma (SCC) is the most common malignancy found on the hands, with reports of this tumor type accounting for 58% to 90% of all

malignancies in this location.^{14–17} This differs from the overall historical skin cancer predominance of basal cell carcinoma (BCC) over SCC.¹⁸ Roughly 15% of all cutaneous SCC are found on the hands,¹⁹ and these tumors metastasize in approximately 3% of cases.²⁰ Signs of malignancy may include rapid changes in size, shape, or color, increasing or new pain, and hand or foot disability. SCC commonly arises on the dorsal hands and fingers in areas of significant sun exposure.

SCC in situ occurs on the dorsum of the hands and feet, and less commonly on the palms or soles, as an asymptomatic erythematous, crusted, or scaly patch or plaque.²¹ SCC in situ is often seen in areas of chronic sun exposure, and invasive progression to SCC is noted in approximately 10% of lesions.²²

High-risk cutaneous SCC occurring on the hands and feet have similar characteristics to similar tumors occurring elsewhere on the body. Features of high-risk SCC include size greater than 2 cm in diameter, poorly differentiated or undifferentiated histology, perineural invasion, or invasion beyond the reticular dermis. High-risk cutaneous SCC has greater potential for local recurrence, metastasis, and disease-specific death,²³ as well as functional morbidity of the hands and feet.

Verrucous carcinoma is a rare variant of squamous carcinoma exhibiting well-differentiated histology, low propensity for metastasis, and aggressive local growth with high risk for local recurrence after treatment. It has been associated with HPV coinfection, and when found on the palmoplantar surface it is often slow-growing and may coexist with other verrucous lesions.²⁴

Basal cell carcinoma

BCC comprises approximately 10% of the malignant diagnoses on the hands.²⁵ There is a male predominance in most cases, often with a history of multiple skin malignancies. BCC rarely metastasizes, but local recurrence rates after treatment vary from 3% to 10% when standard excision or cryosurgery is performed.²²

SCC and BCC of the hands and feet are best treated with excisional surgery. Smaller tumors may be excised successfully with margins in many cases.²⁶ High-risk cutaneous SCC, tumors with ill-defined margins, and

recurrences are best treated with Mohs micrographic surgery.²⁷ Destructive procedures such as cryotherapy and electrodesiccation and curettage are not advised.²²

Melanoma

Hand and foot melanoma, a subset of cutaneous melanoma including nail-unit melanoma and acral lentiginous melanoma, is a poorly described clinical entity with conflicting prognostic data when compared to cutaneous melanomas at other sites.²⁸ Delayed diagnosis and mistreatment are common, and thought to be due to its high frequency in non-Caucasian ethnic populations and amelanotic subclinical presentation.²⁹ UV radiation-induced carcinogenesis likely plays an insignificant role in unexposed areas on the palms and soles.³⁰ Molecular genetic studies of these tumors suggest a lower rate of BRAF mutations and a higher rate of c-kit aberrations when compared to other types of cutaneous melanoma.²⁸

Excisional or incisional biopsies are recommended when a diagnosis of hand or foot melanoma is suspected clinically. Melanoma thickness will impact treatment planning and prognosis.³¹ Shave biopsies on acral locations should be used with caution given the significant thickness of the stratum corneum. Treatment of melanoma of the hands and feet follows guidelines based on size, Breslow thickness, and subungual extension.³² Multidisciplinary care may be needed for digital amputation or sentinel lymph node biopsy for staging. Surgical excision with clear margins is the gold standard of care for melanoma of the hands and feet. Mohs surgery, especially utilizing MART-1 immunohistochemical stains, may provide high cure rates while sparing amputation for digital melanoma (see [Chapter 31](#)).

Epithelioid Sarcoma

Epithelioid sarcoma is the most common soft-tissue sarcoma of the hand, and is a rare, aggressive tumor with high rates of local recurrence and metastasis. It initially presents as a slow-growing, skin-colored, palpable nodule in the deep soft tissue, dermis, or subcutis. It is seen predominantly in younger males on the fingers, hands, and forearms.³³ Misdiagnosis, clinically and histopathologically, is common due to its banal appearance during initial growth and its microscopic similarity to inflammatory granulomatous

conditions.³⁴ By the time diagnosis is made, multiple nodules may be present and pain, drainage, contractures, or neurologic symptoms may have occurred.

The anatomic location of epithelioid sarcoma may influence prognosis, as the proximal type (arising proximal to the elbow or knee) has worse rates of overall survival and metastasis-free survival than more distal tumors.

Treatment involves wide local excision, sentinel lymph node evaluation, and adjuvant radiotherapy.

Merkel Cell Carcinoma

A neuroendocrine carcinoma of the skin, Merkel cell carcinoma (MCC), is an uncommon and aggressive malignancy that develops in sun-exposed areas of the skin. While typically found in elderly or immunosuppressed patients on the head and neck, MCC can occur on the dorsal hands and fingers.

Approximately 10% to 15% of patients with MCC will be present with nodal metastases. Over the course of the disease, a majority of patients will develop metastatic disease. Treatment includes multidisciplinary care involving wide local excision or Mohs micrographic surgery, sentinel lymph node evaluation, and adjuvant radiotherapy. Other rare malignant tumors occurring on the hands and feet include eccrine carcinoma, synovial sarcoma, malignant fibrous histiocytoma, Kaposi's sarcoma, hemangioendothelioma, hemangiopericytoma, angiosarcoma, dermatofibrosarcoma protuberans, and malignant schwannoma.

Benign tumors of the hands and feet

The three most common benign growths of the hands and feet are ganglion cysts (including digital mucous cysts), giant cell tumors (GCTs) of the tendon sheath, and epidermal inclusion cysts.³⁵ Other benign hand tumors include common epidermal lesions such as actinic keratoses, seborrheic keratoses, verruca vulgaris, and knuckle pads. Tumors arising from vascular structures and subcutis include pyogenic granulomas, glomus tumors, vascular malformations, hemangiomas, lipomas, and fibromas. Neural tumors such as traumatic neuromas, schwannomas, and neurofibromas can also be found in acral locations.

Ganglion/mucous cysts

Ganglion cysts are the most common soft-tissue tumor of the hand. They are mucin-filled pseudocysts without a true epithelial lining. Ganglions represent approximately 60% to 70% of all hand tumors and are commonly seen juxtaposed with a joint capsule or tendon sheath.³⁶

Digital mucous cysts are seen on the dorsum of the distal phalanges. These lesions are primarily seen in women, frequently occur in persons aged 40 to 70 years, and more commonly in persons with osteoarthritis.

These lesions may resolve spontaneously, and observation is acceptable.³⁷ Some ganglion cysts may necessitate treatment if drainage occurs at the skin surface, nerve compression, interference with activity, or cosmetic concerns arise.³⁵ Puncture and aspiration result in recurrence in greater than half of cases. Surgical excision is an effective treatment option when the cyst stalk and the joint space are dissected. Intralesional corticosteroid and phenol injections have been reported as effective nonsurgical treatment options.

Giant cell tumors of the tendon sheath

GCTs of the tendon sheath are the second most common tumor of the hand. Other monikers include localized nodular tenosynovitis, fibrous xanthoma, xanthoma of the synovium, benign synovioma, and sclerosing hemangioma.³⁵ Patients often report a slow-growing, lobular nodule along the synovial site of a joint, capsular ligaments, and tendon sheaths.³⁸ Palmar surfaces of the hand are common as well as along the index and long fingers. The nodule does not transilluminate and is firmly affixed to the underlying synovium. High rates of local recurrence after excision are common. Treatment is local excision with meticulous dissection to the intrajoint component, and complete removal.

Epidermal inclusion cysts

Epidermal inclusion cysts are common, painless, subcutaneous, dome-shaped nodules often occurring on the volar surfaces of the hands.³⁵ A central punctum may help aid in the diagnosis. These cysts occur frequently in areas of trauma in patients who are manual laborers, and can be a cause of discomfort upon gripping or if the cyst becomes inflamed or infected.³⁹ Definitive treatment includes excision of the epithelial cystic lining. If

infected, the cyst can be incised and drained, and definitive surgery is delayed until after the inflammation subsides.

RECONSTRUCTIVE APPROACHES

Reconstructive options for the hands and feet are designed to limit patient disability and accelerate postoperative healing to permit rapid resumption of normal hand and foot use. Reconstructive considerations include the size of the defect, the location of the defect, available tissue reservoirs, and the possibility of postoperative wound contraction that would lead to decreased function of the affected extremity.

In order to accurately assess ultimate wound tension, the patient should be asked to make a fist prior to closure design. This maneuver may aid in determining the degree of lateral stress that a given closure will undergo, and can be used to appropriately size a planned flap closure.

Granulation

Allowing a defect to heal by secondary intention is a useful option for many locations on the hand and foot. Due to the highly vascularized nature of the soft tissues in the hand, secondary intention healing may be highly effective. Small defects in virtually any location of the hand or foot can heal well by granulation. Even large wounds, in certain locations, can heal very well without significant scarring or contraction (Fig. 45-9).^{40,41} Occasionally, patient factors such as diabetes, and poor arterial or venous circulation, can lead to prolonged healing of a granulating wound, especially below the knee. A retrospective review of secondary intention healing after excision of acral lentiginous melanoma on the foot showed slower healing with granulating wounds as compared to full-thickness skin grafts, but improved cosmetic and functional outcomes over skin grafting.⁴²

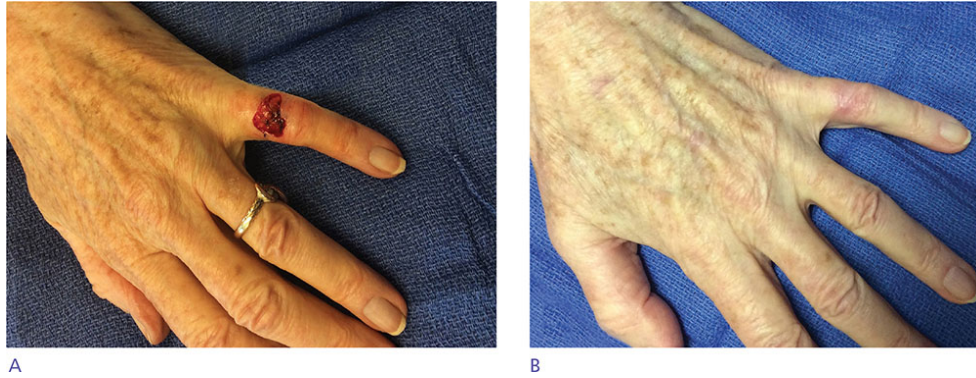


Figure 45-9. (A) Finger defect healed by granulation. (B) Result at 6 months.

Linear closure

On the dorsal hand and foot, linear closure is a first-line option for patients with sufficient skin mobility (Fig. 45-10). The relatively atrophic skin of the hands may require special attention to suturing technique; set-back dermal sutures, rather than buried vertical mattress sutures, may permit a more secure dermal bite, and percutaneous approaches may be utilized as well. Utilizing a smaller diameter suture may be helpful as well, with the added advantage of inserting less foreign body material into an area with an already minimal dermis. Pulley approaches of the above techniques may be occasionally used to avoid suture pull through or help close a defect under tension, though if marked tension is present consideration should be given to other closure approaches. Alternatively, transepidermal sutures can be used to close the wound under tension, as the thicker stratum corneum found on the hands and feet may support the suture material without tearing. Suturing through a polyethylene film, surgical glue, or adhesive strips to artificially thicken atrophic skin on the dorsal hand has also been described,^{43,44} though this option should only be exercised if dermal sutures cannot be placed due to extreme atrophy.

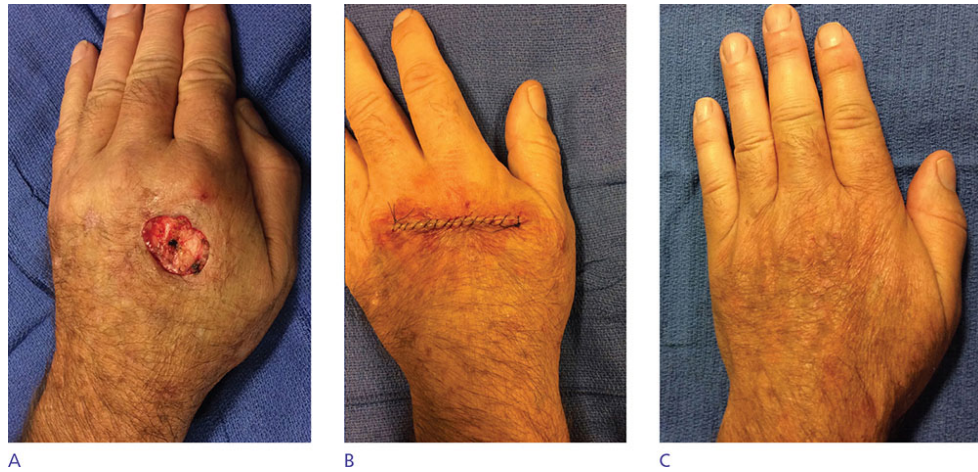


Figure 45-10. (A) Defect after removal of tumor by Mohs surgery. (B) Linear closure. (C) Healed result.

Alternatively, purse-string closure, with or without central secondary intention healing, may decrease the size of the surgical defect and decrease the healing time overall for the patient, though a recent randomized, controlled trial suggested only minimal benefit to this approach.

Full-thickness skin grafts

Full-thickness grafting is an excellent option for many wounds on the hand and foot that are not amenable to simple closure. Studies have shown excellent FTSG survival rates of a vast majority of grafts placed on the lower extremity.⁴⁵ The technique for skin grafting on the hands and feet is similar to that on other areas of the body; the donor site can be nearly any location with enough tissue laxity to harvest a full-thickness graft. Indeed, Burow's graft, abdomen, supraclavicular area, and upper arm are all commonly used areas. The donor tissue is thinned to dermis and then sutured into the defect. In most cases superficial sutures only are used. The graft is immobilized with either tacking sutures or a bolster and dressed with petrolatum, petrolatum-impregnated gauze, a nonadherent dressing, and a light pressure dressing. This dressing remains in place for 1 week, and the patient is instructed to keep the bandage dry and elevate lower extremity wounds as much as possible (Figs. 45-11 to 45-14).



Figure 45-11. (A,B) Squamous cell carcinoma on fifth finger and resulting defect after Mohs surgery. (C) Full-thickness skin graft from upper arm donor site placed. (D) Healed result on upper arm donor site. (E) Healed result on fifth finger.

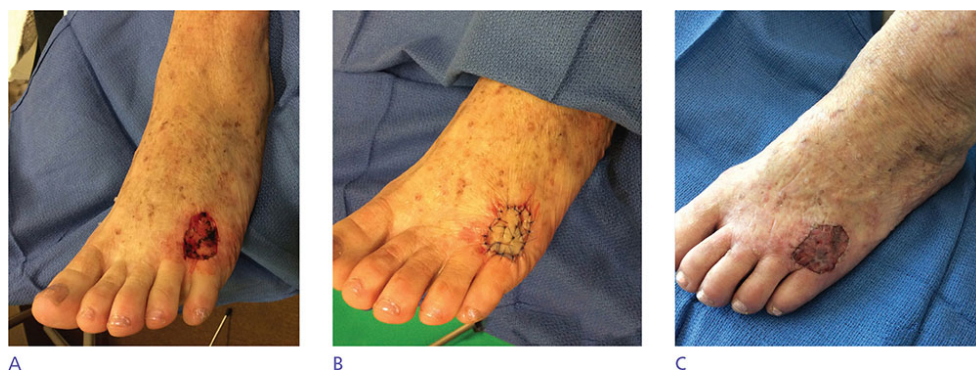


Figure 45-12. (A) Defect on dorsal foot after removal of tumor. (B) Full-thickness skin graft placed. (C) Result at suture removal (2 weeks).

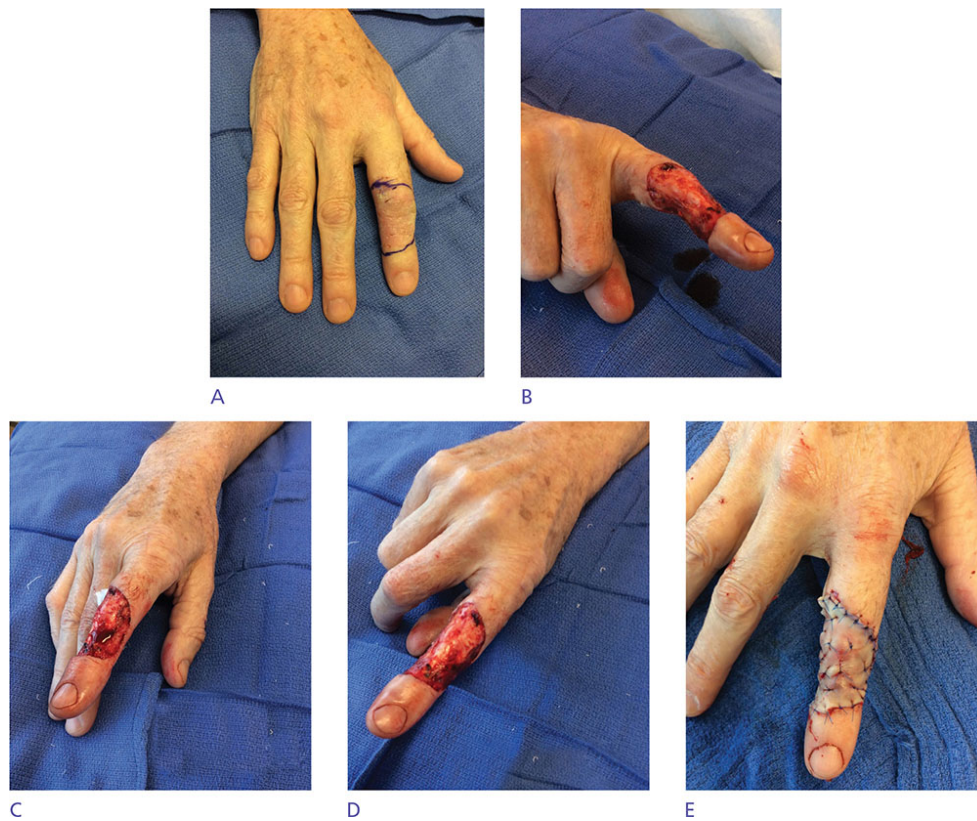


Figure 45-13. (A) Squamous cell carcinoma in situ. (B–D) Final defect almost circumferential around index finger. (E) Full-thickness skin graft repair.



Figure 45-14. (A) Defect after removal of basal cell carcinoma on dorsal hand with Mohs surgery. (B) Full-thickness skin graft sutured into place. (C) Healed result at 1 year.

Split-thickness skin grafts

Split-thickness skin grafts are generally straightforward to harvest and are easily fenestrated to provide coverage for larger wounds. Their lower metabolic requirements should be weighed against their tendency toward contraction. There is increased risk of contracture for palmar hand split grafts, as compared to dorsal hand split grafts, even if they extended onto the digits,⁴⁶ though the incidence of contractures was lowest for split-thickness finger-only grafts.

In selected surgical defects that do not pose a risk of contracture, these grafts may be used safely with no functional impairment. The graft is performed as it would be elsewhere on the body. The preferred donor site is the thigh, and an electric dermatome or Weck blade is used to harvest a 0.10- to 0.20-cm thick graft. The graft can then be placed on the wound with or without meshing, which can be performed by hand or with a meshing device, and which may expand the graft surface area up to nine times.⁴⁷

LOCAL FLAPS

Transposition flaps

Transposition flaps (Fig. 45-15) are most commonly used to cover medium-sized defects on the dorsal hand that are not amenable to primary repair. The flap is designed to recruit lax skin proximal to the defect, and may be undersized if there is sufficient secondary motion around the defect to close the area. These flaps are generally used on the midproximal hand and on the fingers.

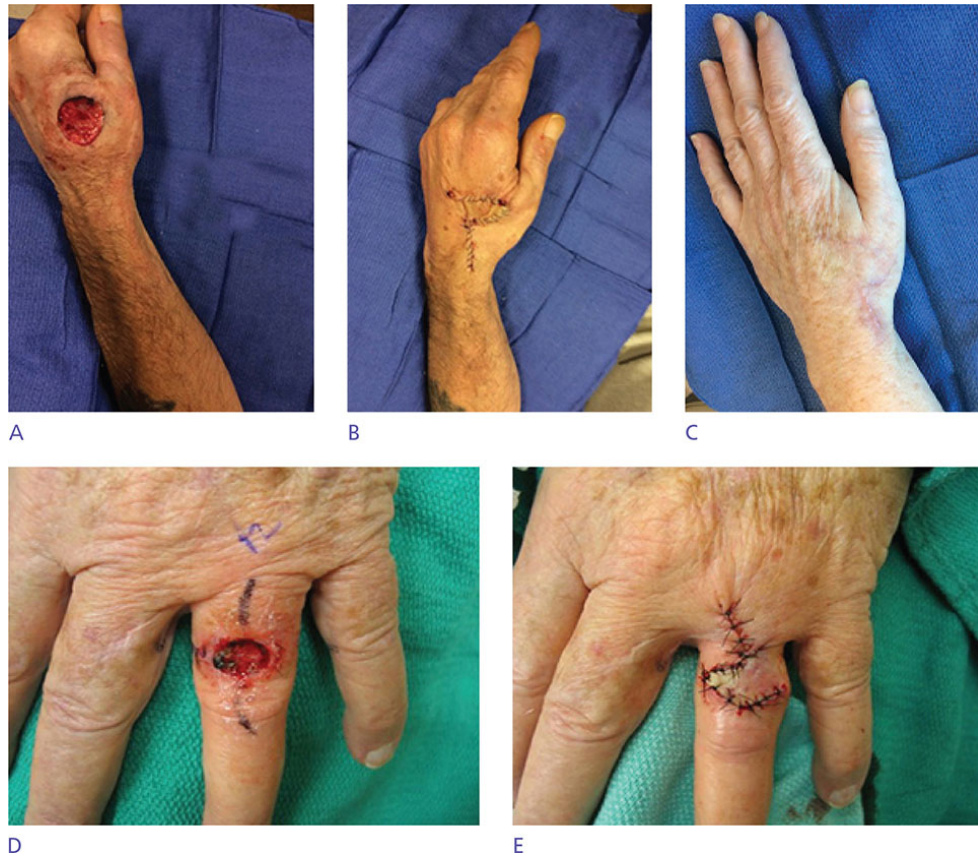


Figure 45-15. (A) Defect after Mohs surgery for SCC on dorsal hand. (B) Transposition flap designed proximal to the defect and sutured into place. (C) Healed result at 3 months. (D) Defect on finger after Mohs procedure. (E) Transposition flap from dorsal hand to finger.

Rotation flaps

A rotation flap may be used to close defects under significant tension. Curvilinear incisions are made into the area of the most skin laxity to create a unilateral or bilateral rotation flap. Special attention must be given to the challenge of pivotal restraint. Dog-ears may be removed or sewn out through the length of the flap (Fig. 45-16).



Figure 45-16. (A) Defect on dorsal foot after removal of SCC with Mohs surgery. (B) Bilateral rotation flap (O to Z) designed and sutured into place.

Fasciocutaneous flaps

Local fasciocutaneous flaps on the hand and foot can be used as a reconstructive option for small- to large-sized defects, and may be useful as an alternative to skin grafts. The keystone flap may be useful for this purpose,⁴⁸ as its blood supply is based on random vascular perforators. Undermining on the hand can be performed at the level of the dorsal superficial fascia, the dorsal deep fascia, or both, to create a one- or two-sided sling flap (Fig. 45-17). The advantage of undermining in a deep plane is to convey greater movement to the flap, though this may also sever more of the perforating vasculature. Undermining in the more superficial fascial plane preserves more vascularity, but also restricts the flap motion. A combination approach to undermining may achieve adequate motion while preserving blood supply to the flap.⁴⁵ It is important not to overly undermine fasciocutaneous flaps, as this may sever the perforating vessels leading to vascular compromise.

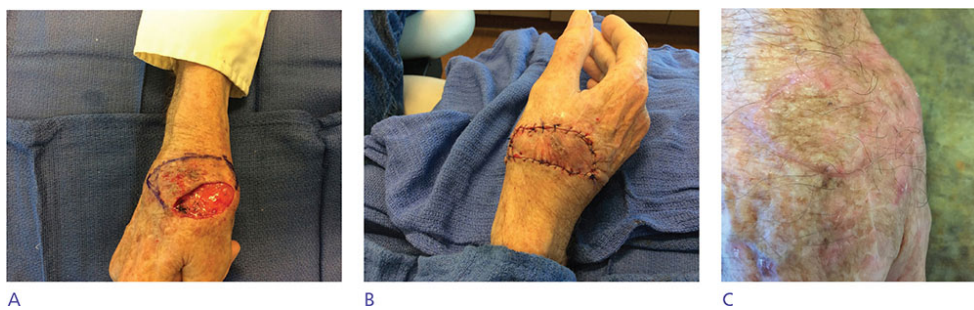


Figure 45-17. (A) Defect after removal of SCC on dorsal hand with keystone flap designed. (B) Keystone flap on dorsal hand sutured into place. (C) Healed result at 1 month.

With a traditional keystone flap design, the incision of all the limbs of the flap is carried down to the deep fascia, (Fig. 45-17) and the tension is shared between the defect and the donor site. In a modified keystone flap design, a sling flap is created by incising and undermining to dorsal superficial fascia on one or two sides of the flap and to dorsal deep fascia on the remaining side.⁴⁹ The propeller flap, a variant of the island pedicle flap that can be rotated 90 to 180 degrees to cover a defect, is also sometimes useful for hand reconstruction (Fig. 45-18).⁵⁰



Figure 45-18. (A) Deep defect to bone on index finger. (B) Propeller flap designed on dorsal hand and rotated 180 degrees to close defect. (C) One-day follow-up showing good perfusion of flap. (D) Two-week suture removal showing excellent flap viability.

Cross-finger flap

The cross-finger flap is an axial flap used to cover defects of the volar aspect of the fingers. Advantages of this flap include the ability to create a sensate, vascularized surface. The flap is raised from the dorsal aspect of a radial digit, and in cases involving the index finger, the middle finger is

typically utilized. The flap relies on collateral flow through the contralateral digital artery, with the pedicle consisting of a digital artery, venae comitante, and digital nerve.

The flap is designed with the hinge of the flap based on the side of the finger closer to the defect (Fig. 45-19). The amount of tissue needed is measured, and an appropriately sized flap is designed. Skin and subcutaneous tissues are elevated in the plane above the epitenon. The flap is opened like a book cover, turned 180 degrees, and inset into the defect (Fig. 45-20). Suture or pin placement between the fingers helps to prevent flap dehiscence. A full-thickness skin graft is placed on the donor site and is secured with a bolster. The flap is typically divided after 3 weeks (Fig. 45-21), and finger range-of-motion exercises are started immediately. Long-term follow-up is shown in Figure 45-22. Disadvantages of this approach include the need for a secondary procedure, restricted range of motion between flap insertion and takedown, and stiffness.

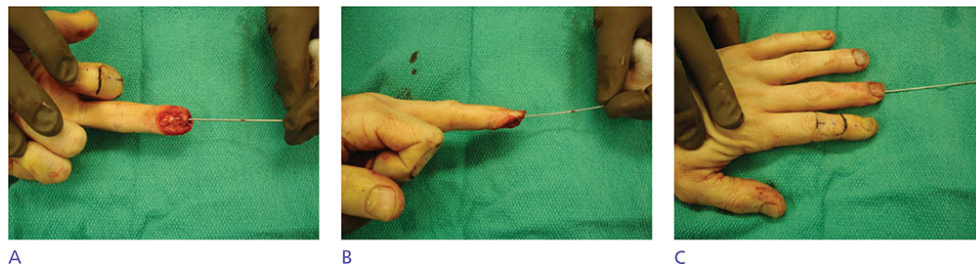


Figure 45-19. (A,B) A soft-tissue defect with exposed bone is present on the volar surface of the distal phalanx of the middle finger. (C) Donor site on index finger is shown.



A



B

Figure 45-20. (A) The flap is inset using 5-0 nylon sutures. (B) Tension can be adjusted through the addition of additional 5-0 chromic suture.



Figure 45-21. The flap is taken down 3 weeks after the index procedure.

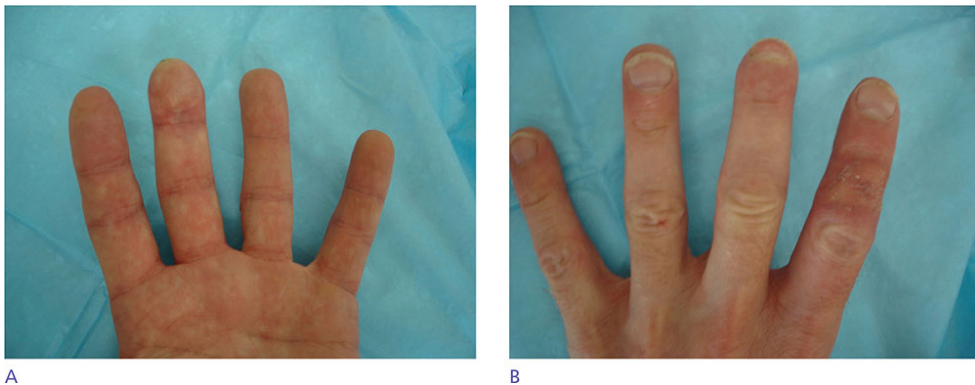


Figure 45-22. (A,B) Follow-up at 3 months demonstrates healed wounds with return of normal function.

Reverse cross-finger flap

Adequate coverage for dorsal finger wounds of the distal and middle phalanx represents a clinical challenge, and the reverse cross-finger flap can provide coverage for these wounds (Fig. 45-23). The flap is raised from a neighboring digit, with the base of the hinge centered away from the finger requiring coverage. The size of the defect to be addressed is measured, and an appropriately sized incision to cover the donor digit is made. The hinge of the skin flap is centered over the midlateral portion of the phalanx. The skin is elevated sharply. Care must be taken to elevate only the skin, leaving as much of the underlying tissue intact as possible. After the skin is elevated, the subcutaneous tissues are elevated with the tissue hinge toward the area of the deficit (Fig. 45-24). The epitenon immediately overlying the extensor tendon is left intact. The subcutaneous tissues are then elevated and placed over the defect. A full-thickness skin graft can then be applied over the recipient site on top of the grafted subcutaneous tissue. A splint can be placed involving the affected digits to protect the flap, and wound healing is assessed weekly. The bolster is removed at the first postoperative visit, and the flap is taken down after 3 weeks (Fig. 45-25). A course of immediate occupational therapy may be started to facilitate motion and return to normal function (Fig. 45-26).



Figure 45-23. (A) dorsal fingertip defect is present with exposed tendon and bone.



Figure 45-24. The reverse cross-finger flap has been inset. The donor site skin flap is closed primarily and a full-thickness skin graft is placed over the recipient site.



A



B

Figure 45-25. (A,B) Appearance of the flap after takedown at 3 weeks following the index procedure.



A



B

Figure 45-26. (A,B) Follow-up images taken at 3 months demonstrate healed graft with preserved finger contour.

Other flap approaches to hand reconstruction

A wide array of flaps of varying complexity have been described for hand reconstruction, including the V-Y flap, thenar flap, Moberg flap, axial flag flap, and kite flap. An absolute prerequisite for all of these approaches is a comprehensive understanding of hand anatomy coupled with a strong grounding in surgical technique.

Skin scaffolds and skin substitutes

Allografts

Skin scaffolds provide a unique method to facilitate skin closure. They function through providing a dermal alternative to promote wound healing or create an environment that is amenable to skin grafting. Numerous options exist including Dermagraft (Organogenesis, Canton, MA), Integra (Integra Lifescience, Plainsboro, NJ), and Apligraf (Organogenesis, Canton, MA) among many others.

Though each manufacturer provides unique recommendations regarding the product use, common themes and principles are involved in utilizing skin scaffolds. Prior to their use, a clean, hemostatic wound bed must be prepared. The scaffold may be applied with an overlying bolster or underlying vacuum-assisted closure to prevent fluid accumulation and facilitate integration. Weekly follow-up is undertaken. Typically wounds are covered with full- or split-thickness skin grafts at 3 weeks.⁵¹

Acceptable outcomes have been reported with placement directly onto bone and tendon. Multiple layers of these scaffolds can be used in order to restore soft-tissue contours in cases of large defects.⁵²

Xenografts

Bovine and porcine xenografts have been studied for healing wounds in human subjects. The most common type of xenograft used in repair of Mohs defects is porcine. Porcine xenograft confers the advantage of being a quick and technically simple repair; however the “graft” is not meant to “survive” on the human body. Instead, the xenograft functions as a wound matrix to cover the wound bed and facilitate granulation and angiogenesis.⁵³ Porcine xenografts may be fixed in place using absorbable sutures, and are bandaged as full-thickness skin grafts or hydrocolloid dressing (Figs. 45-27 and 45-28).



Figure 45-27. (A) Amelanotic melanoma of the palm removed by Mohs surgery. (B) Porcine xenograft reconstruction. (C) Early granulation. (D,E) Healing at 4 months without significant contraction.

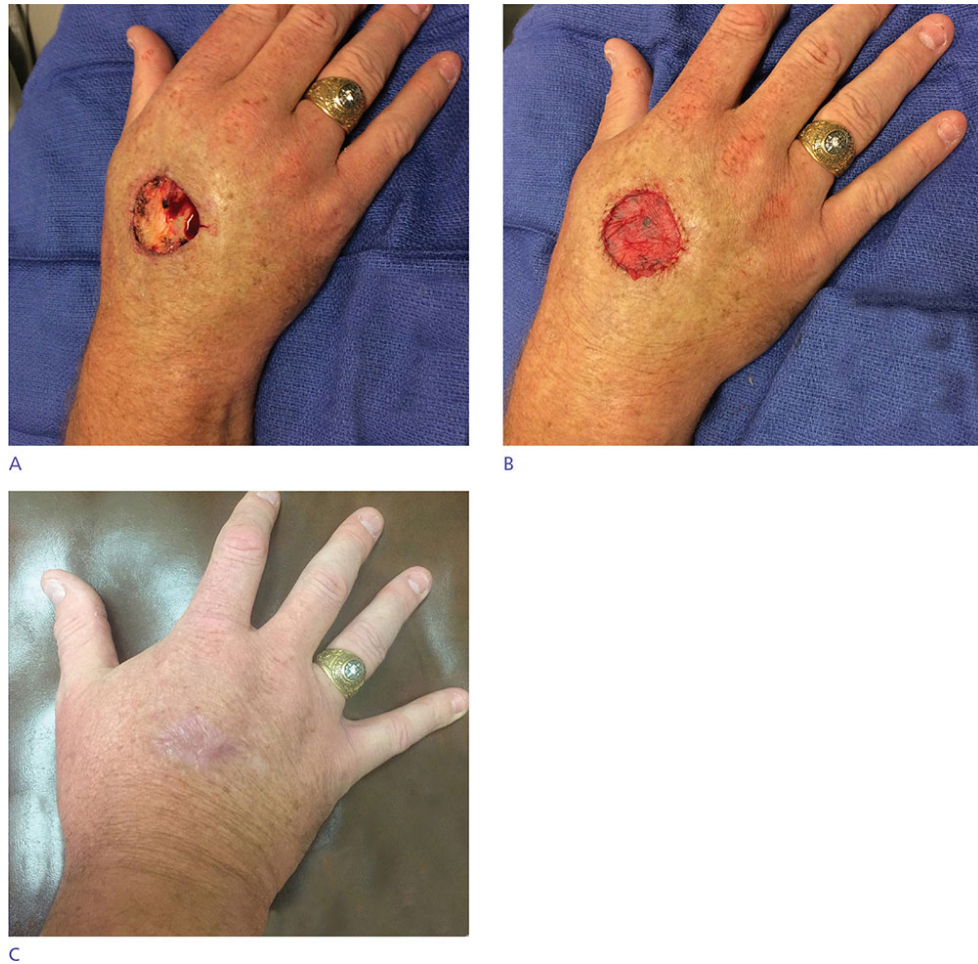


Figure 45-28. (A) Defect after Mohs surgery. (B) Porcine xenograft sutured into place. (C) Final healing.

POSTOPERATIVE CARE

Splinting of the hand is a vital part of postoperative care, and has a marked impact on recovery and outcomes. A period of immobilization permits improved comfort for patients and facilitates tissue healing.

The *minimal* amount of immobilization that can be used should be utilized, which helps to facilitate rapid recovery and prevent stiffness in uninvolved joints. Standard postoperative dressings can be placed over a wound, and a splint is simply applied over the dressing. Splints should be kept clean and dry in order to prevent moisture buildup, which may lead to skin breakdown and infection.

For repairs near the wrist, it may be immobilized with a simple volar resting splint. A layer of stockinet can be applied if desired. Padding is placed circumferentially around the wrist extending to the forearm. A final layer of elastic bandage is then applied. The ideal position for the wrist is at neutral or 10 to 15 degrees of extension, though the splint can be modified as needed (Fig. 45-29).



Figure 45-29. (A–E) Splinting of the hand and wrist.

Finger immobilization may provide an increased level of comfort following soft-tissue procedures. The minimum number of joints is immobilized in order to protect the surgical site, while allowing for maintained motion in the uninvolved areas. A custom splint can be cut from a piece of alumafoam and secured to the finger with a self-adhesive dressing (Fig. 45-30). A tongue depressor can also be used as a makeshift finger splint (Fig. 45-31).



A



B

Figure 45-30. (A,B) The alumafoam splint may be applied on the dorsal, palmar, or both surfaces of the finger.

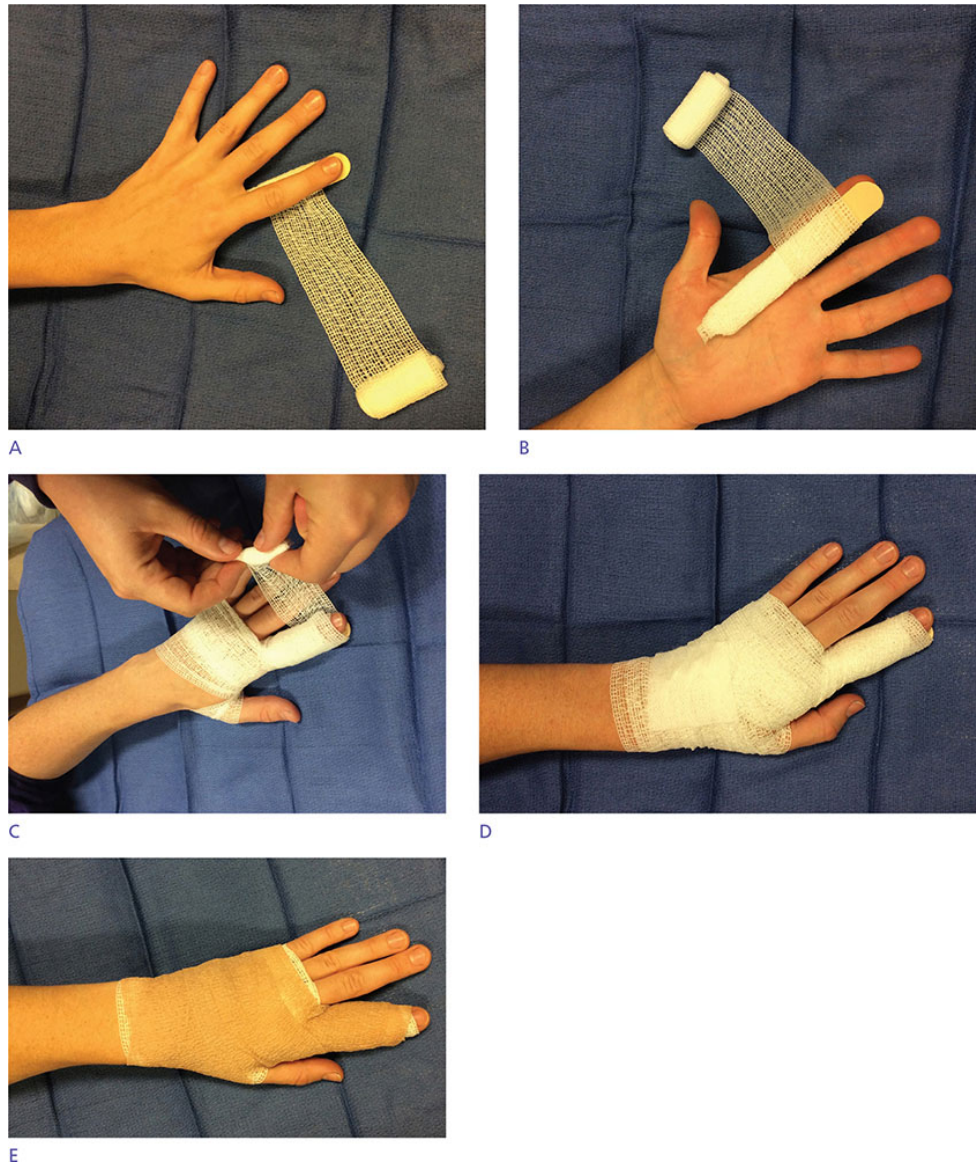


Figure 45-31. (A,B) Tongue depressor used as a finger splint. (C,D) Wrapped with Kerlix gauze around hand and finger. (E) Coban wrap secures final bandage.

CONCLUSIONS

Surgical reconstruction of the hand and foot encompasses an array of repair options, from secondary intention healing for small or superficial wounds to multistaged flaps. Appropriate patient selection is of vital importance, as patients should be highly motivated and able to comply with immobilization and wound care requirements if complex flap procedures are planned. Given the aesthetic and functional importance of the hand and foot, such repairs

should only be undertaken by experienced surgeons comfortable with the complex anatomical and functional considerations inherent in hand surgery.

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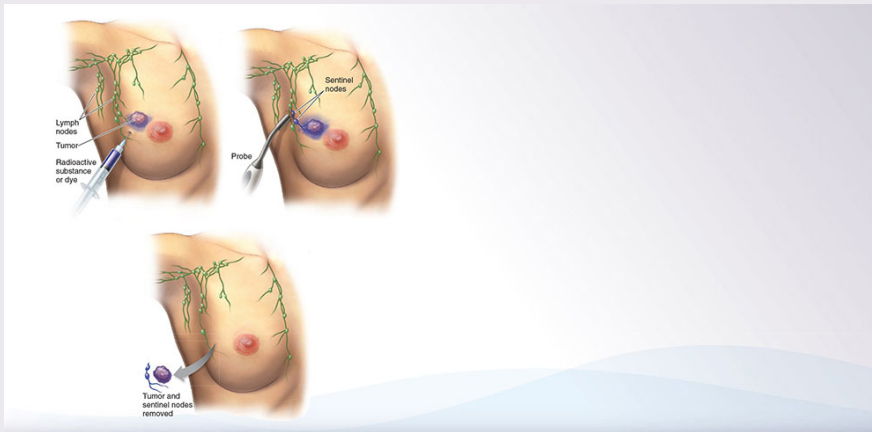
Part IV

SURGICAL APPROACHES BY DISEASE STATE

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CHAPTER 46 Melanoma

Derek J. Erstad
Kenneth K. Tanabe



SUMMARY

- Melanoma is the most lethal form of skin cancer, accounting for an estimated 76,380 new cases and 10,130 deaths in the United States each year.
- Though medical management of melanoma has improved markedly over the past several years, surgical treatment remains the mainstay of early melanoma management.

Beginner Tips



- Thorough physical examination is required at diagnosis and preoperative evaluation, and any clinically apparent nodal metastases should be confirmed via FNA.
- A complete staging workup is required after confirmation of nodal metastases.
- As a general rule, all melanoma excisions should be taken to the level of the fascia.

Expert Tips



- SLNB should be considered for melanomas greater than 1 mm in depth.
- Combination blue dye and ^{99m}Tc permits SLN detection of at least 98%, though SLN detection in the head and neck is particularly challenging.
- Extensive or recurrent melanoma on the extremity may be treated with adjuvant hyperthermic isolated limb perfusion, though this approach has significant morbidity as well.

Don't Forget!



- Melanomas on the trunk may drain to contralateral or multiple basins.
- Effective SLNB is contingent on close coordination between the surgeon, the nuclear medicine specialist, and the pathologist.
- Lymphoscintigraphy with SLNB has had the greatest effect on patients with microscopic nodal metastases.

Pitfalls and Cautions



- Complication rates from lymph node dissection range from 50% to 90%.
- Experience with SLNB has a significant impact on the ability to reliably reduce nodal relapse. It remains unclear whether patients with positive SLNB would benefit from complete LND.

Patient Education Points



- Preoperative consultation should include not only general education regarding the nature of the disease, but also the morbidity associated with various approaches.

- Given the very high rate of complications, patients must be informed regarding these risks well ahead of surgery and should be highly motivated.
- In general, once patients understand the significant mortality associated with the disease, the morbidity associated with SLNB and CLND are more palatable.

Billing Pearls



- Elliptical melanoma excisions are generally coded with the malignant excision code series (11600 series) and the intermediate (12030 series) or complex repair (13101 series) codes, depending on the complexity of closure.
- SLNB is generally not performed by dermatologic surgeons in the United States.

CHAPTER 46 Melanoma

INTRODUCTION

Melanoma is the most lethal form of skin cancer. In 2016, there were an estimated 76,380 new cases (21.8 per 100,000) and 10,130 deaths (2.7 per 100,000) from the disease in the United States.¹ The annual incidence is projected to increase to 230,000 by 2030, due to several factors including better detection and reporting, an aging population, and continued high-risk behaviors.² Innovations in targeted molecular and immunotherapies have advanced our ability to treat disseminated disease, though surgery remains the mainstay of curative therapy for patients with early-stage melanoma. Over the last several decades, melanoma surgical procedures have been evaluated and optimized for effectiveness and safety, and most aspects of treatment have been standardized. This chapter focuses on the current surgical principles of melanoma surgery, including preoperative evaluation and testing, biopsy techniques, wide local excision (WLE) for primary cutaneous disease, sentinel node sampling, treatment of regional disease with lymphadenectomy and isolated limb perfusion and infusion, and the role of surgery for distant metastases.

PREOPERATIVE EVALUATION

Preoperative evaluation begins with clinical history and physical examination. In most cases, a diagnosis will have been established prior to surgeon evaluation. The patient should be screened for symptoms of metastatic disease (constitutional, lymphatic, hepatic, pulmonary, gastrointestinal, skin, musculoskeletal, neurologic review of systems). Physical examination includes inspection of the primary lesion, as well as

thorough examination of the entire skin, including the hairy scalp, and oral and genital mucosa to assess for satellite or synchronous lesions. Careful palpation of all nodal basins should be performed, as well as palpation for in-transit metastases. For asymptomatic patients diagnosed with primary melanoma without clinical evidence of nodal spread, there is no evidence to support routine laboratory or imaging investigations for metastatic disease. These tests have high false-positive rates, resulting in more unnecessary testing and anxiety. A focused investigation for distant disease should only be pursued based on objective signs or symptoms.³

Clinically palpable nodal metastases will be present at the time of diagnosis in a small percentage of patients. Nodal spread should be histologically confirmed, preferably with fine needle aspiration (FNA), which can be done either by palpation or with ultrasound (US) guidance in the outpatient setting. Other biopsy methods include core, incisional, and excisional techniques, which are more invasive and rarely necessary. In some cases, palpable nodes represent reactive lymphadenopathy resulting from local inflammation at the primary biopsy site. Nodal basin US may be considered for equivocal nodal examination findings, though there is no evidence for the use of screening US as a replacement for sentinel lymph node biopsy (SLNB) in clinically node-negative patients.⁴ A complete staging workup is required after confirmation of nodal metastases. This includes magnetic resonance imaging (MRI) of the brain, and imaging of the chest, abdomen, and pelvis with computed tomography (CT), positron-emission tomography (PET), or both. For melanoma of the extremities and head and neck, axial CT imaging of the affected nodal basin is helpful to determine disease burden for operative planning.³ A summary of recommended components for preoperative clinical evaluation is shown in Table 46-1.

Table 46-1. Key Points for Preoperative Evaluation of Melanoma Patients

History	■ Assess for signs and symptoms of distant spread (constitutional, lymphatic, hepatic, pulmonary, gastrointestinal, skin, musculoskeletal, neurologic review of systems)
Clinical examination	■ Full body skin and mucosa examination ■ Palpate for enlarged nodes, in-transit metastases
Sampling of enlarged nodes	■ FNA by palpation or US guidance in clinic
Laboratory studies	■ Not indicated in asymptomatic patients without clinical nodal involvement
Imaging studies	■ Screening for distant disease not indicated in asymptomatic patients without clinical nodal involvement ■ Clinical nodal disease full staging evaluation: MRI brain, CT chest, abdomen and pelvis, and/or PET ■ Axial imaging of involved nodal basin recommended for operative planning

CT, computed tomography; FNA, fine needle aspiration; MRI, magnetic resonance imaging; PET, positron-emission tomography; US, ultrasound.

Cutaneous biopsy techniques for melanoma

For undiagnosed patients presenting with an abnormal pigmented skin lesion, multiple biopsy techniques are available. Breslow depth is the most important histopathologic prognostic determinant in melanoma, and is used to guide excision margin width and indication for SLNB.⁵ Choice in biopsy technique is influenced by several factors including physician specialty, resources, and efficiency. Excisional biopsy with 2-mm margins is ideal for highly clinically suspicious pigmented lesions, though it is more time-consuming than shave biopsy, and a deep (scoop) shave biopsy is usually adequate for most lesions.⁶ Bolshinsky et al. evaluated their experience of 807 WLE specimens after diagnosis with complete excisional biopsy, and found residual disease in 4.2% of cases, with predominance of lentigo melanoma subtypes.⁷ WLE is not recommended for initial treatment due to the low incidence of melanoma diagnosis among all pigmented lesions, as well as potential impact on sentinel node mapping. There is no role for frozen sectioning in melanoma biopsy.

Particularly with melanoma, partial biopsy techniques including shave and punch are subject to error, though debate continues whether the degree of error is within an acceptable range.⁸ Inaccurate biopsy sampling may result in incorrect staging, inadequate subsequent wide resection margin, and missed indication for SLNB. Several studies have evaluated partial biopsy in cutaneous melanoma, and found that it has no influence on prognosis. Molenkamp et al. reviewed their experience with 471 melanoma patients, and concluded that neither the biopsy method nor the presence of cells at the deep margin during excision had a detrimental effect on survival.⁹ More recently, Mills et al. evaluated 709 melanoma patients, of which 23% underwent punch biopsy and 34% underwent shave biopsy. Partial biopsy

techniques resulted in more positive margins at WLE, but had no impact on disease-specific survival.¹⁰ Similarly, Mir et al. reviewed their experience of 479 patients, and found significantly higher primary lesion transection rates with partial biopsy techniques, though no effect on overall survival.¹¹ Egnatios et al. reviewed 609 melanoma patients, 70% underwent shave or punch biopsy, 39% had positive margins after biopsy, and 10% had tumor upstaging after WLE, though none of these factors influenced overall survival on multivariate analysis.¹² In addition, there is no evidence that partial biopsy may result in increased sentinel lymph node (SLN) micrometastases or locoregional and distant recurrences.¹³

With shave biopsy, there is risk of potentially transecting the base of the lesion, and approximately 20% of lesions will have a positive deep margin at the time of surgery.⁶ Kaiser et al. reviewed 853 patients with cutaneous melanoma that underwent shave biopsy, and found that this technique underestimated the depth of lesions by over a millimeter in 12.5% of patients, of which 4.7% required further surgery after initial WLE.¹⁴ In a separate review of 600 patients by Zager et al., the margin of error was lower; only 3% of lesions were upstaged at WLE, 2% required additional WLE, and 1% required SLNB.⁸ Mir et al. reviewed 240 cases, of which 128 underwent shave biopsy. Of these, 22% had positive deep margins, a significantly greater proportion than with punch or excisional techniques.¹¹ This was corroborated in a review of 240 cases by Stell et al., who similarly had a deep positive margin rate of 22% with shave biopsy.⁶ For this reason, most dermatologists who perform shave biopsies for melanoma tend to take a deep and broad sample (scoop shave), and this tendency likely explains the broad variation in positive deep margins between studies. The American Academy of Dermatology consensus statement suggests an excisional biopsy, but includes a deep scoop shave as an excisional technique. Therefore, if a shave biopsy is performed, it should be of ample breadth and depth to capture the full extent of the tumor.

Punch biopsy can be a useful technique under appropriate circumstances, and though this approach often leaves a positive peripheral margin, it is effective for measuring the depth of invasion. Biopsy should be taken from the most raised or pigmented area, which presumably corresponds to the deepest portion of the lesion, though this is subject to error. If there is significant clinical heterogeneity to the lesion, multiple punch samples may

be taken, with emphasis on evolving regions. Hieken et al. reviewed their experience with 332 cutaneous melanoma patients, and found that T-stage changed in 8% of patients, of which 59% underwent punch biopsy, and treatment recommendations changed in 18% of punch biopsy patients.¹⁵ Ng et al. reviewed 2,470 melanoma biopsies, including excisional, shave and punch specimens. They found a 3.4% rate of false-negative misdiagnoses, the majority stemming from partial biopsy techniques (punch OR 16.6, $p < 0.001$; shave OR 2.6, $p = 0.02$; relative to excisional). Partial biopsy was associated with increased microstaging error as well (punch 34%, OR 5.1, $p < 0.001$; shave 19%, OR 2.3, $p < 0.001$; relative to excisional). Misdiagnosis and inaccurate microstaging resulted in 37 (1.5%) adverse outcomes, all related to the persistence or progression of primary disease. General practitioners were six times more likely than dermatologists to misdiagnose with partial biopsy techniques. Acral lentiginous, desmoplastic, and nevoid melanomas were most commonly subject to inaccurate diagnosis and staging.¹⁶ The high probability of positive peripheral margins and an approximately 10% to 20% chance of tumor upstaging on final pathology should be considered when approaching wide excision for patients after punch biopsy. A summary of biopsy techniques in melanoma is listed in Table 46-2.

Table 46-2. Melanoma Biopsy Techniques

Biopsy Technique	Advantage	Disadvantage	Margin
Excision	Complete specimen evaluation	Time, operative skill required, suturing, risk of wound complications	1–2 mm throughout; 4% positive margin
Punch	Accurate measurement of depth of invasion, useful for large lesions or cosmetically sensitive areas, ease of use, efficiency	Positive peripheral margin, missed sampling of deepest portion, suture closure (depending on size)	Positive peripheral margin (majority of cases); 10–20% positive deep margin
Shave	Complete peripheral evaluation, ease of use, efficient, no suturing	Positive deep margin frequent, 3–5% upstaging error	20+% positive deep margin when not performed as a scoop shave

Anesthesia for melanoma surgical procedures

Surgical excision is the mainstay of curative therapy for early-stage melanoma, and provides local control of the primary lesion. Initial treatment involves WLE, with possible SLNB or lymph node dissection. The choice of anesthetic is predicated on the size and location of the planned excision, as well as the need for node sampling. In general, WLE alone can be

accomplished with local anesthesia, or, for more involved excisions, conscious sedation under monitored anesthesia care (MAC). Lymph node dissection of the neck, axilla, groin, or iliac basins requires more extensive incisions and tissue manipulation, and should be performed under general anesthetic. For patients requiring general anesthesia, preoperative clearance based on consensus guidelines from the American College of Cardiology and American Heart Association should be performed.¹⁷

For local anesthesia, many options are available, and a mix of short- and long-acting anesthetics (1% lidocaine mixed 50:50 with 0.5% bupivacaine and epinephrine) may provide faster onset and longer duration of action. A ring block may be useful as well. Once the superficial layers have been infiltrated, the subcutaneous space may be infiltrated as well.

Surgical principles of wide excision in melanoma

Multiple factors impact surgical planning for excision of primary cutaneous melanoma, including histologic subtype, size and location, depth of invasion, need for future lymph node sampling/dissection, cosmesis, and need for reconstruction (Table 46-3). The ultimate goal of a sound oncologic resection must be balanced against the morbidity, functional, and cosmetic considerations of aggressive intervention.

Table 46-3. Factors to Consider in Wide Excision for Melanoma

Factor	Considerations
Type of lesion	■ Lentigo maligna, often found in sun-exposed regions the elderly, may cover multiple square centimeters, resulting in a large excision defect ■ Nodular, dermal, and amelanotic melanoma are frequently larger than what appears to the naked eye
Location	■ Should have good knowledge of surface anatomy and anatomic danger zones prior to excision ■ Lesions overlying thin soft-tissue covering (face, hands, feet), may require dissection to underlying structures including tendon or ligament ■ Head/neck and distal extremities have less tissue domain for closure; may require flaps, grafting, or complex reconstruction ■ Extensor surfaces are at greatest risk for dehiscence, and may require layered closure, as well as release of subcutaneous skin flaps to provide optimal strength and minimize tension ■ Consider temporary joint immobilization for lesions at risk of increased tension and dehiscence ■ Acral melanomas may require amputation of involved digit to obtain sufficient soft-tissue margins
Depth of invasion	■ Margin width based on depth, ranges from 5 mm to 2 cm ■ Necessity of wide margins results in excisions that are significantly larger than the original lesion, requiring considerable preoperative planning
Lymph node mapping	■ Elliptical excisions on the extremities should be longitudinal along the axis of the extremity to reduce the extent of lymphatic disruption
Cosmetic sensitivity	■ Cosmetically sensitive regions include the ears, face, head, and neck ■ If possible, confine the excision to regions of shared skin color and texture, hair content, sebaceous gland production ■ S-plasty can reduce scar formation along convex, longitudinal surfaces ■ Skin tension lines run perpendicular to muscle contraction; incisions along tension lines are under less stress, have reduced scarring and stretch over time, and are better hidden
Flaps	■ Subcutaneous release flaps reduce tension on the skin closure in regions of limited soft-tissue domain ■ Subcutaneous flaps are easily made with Metzenbaum or Mayo scissors, knife, or electrocautery by creating a dissection plane along the length of the excision that is tangential to the surface, above Scarpa's fascia. Subcutaneous flaps typically extend several centimeters beyond the excision edge to create enough laxity for adequate closure ■ Complex flap reconstruction, e.g., fascial, perforator, and muscle flaps, are rarely necessary, but reserved for large tissue defects in regions of limited tissue domain and vulnerable underlying structures including bone, nerve, or vessels
Skin grafts	■ Partial-thickness advantages: high rate of successful graft take, can cover large surface area, low risk to donor site (10–14 mm epidermal shave) ■ Partial-thickness disadvantages: poor cosmetic result, tissue step-off at excision edge, meshing scar pattern, donor site discoloration, donor site pain ■ Full-thickness advantages: better cosmetic result, more durable ■ Full-thickness disadvantages: lower rate of successful graft take, requires surgical excision of donor site, limited surface area coverage

The majority of primary cutaneous melanomas are excised with an elliptical incision to permit primary closure. A long and narrow ellipse (at least 3:1) with apices of 30 degrees or less is designed (Fig. 46-1). The incision may also be tapered at the corners to acutely narrow the apical angles.



Figure 46-1. Wide local excision surgical field prepped and draped.

Since electrocautery artifact may confound the histopathologic evaluation, melanoma excision is best performed with a scalpel (Fig. 46-2). When cutting through the dermis with the scalpel, a single, continuous cut through the entirety of the dermis should be made. This obviates the risk of multiple slashed cuts that may result in a weakened, irregular skin edge and encouraging overhanging dermis.



Figure 46-2. Wide local excision of melanoma with scalpel.

The specimen is oriented with a suture at one apex for pathological evaluation ([Fig. 46-3](#)), and the wound is surveyed for hemostasis. Hemostasis is obtained with electrocautery either directly applied to bleeding vessels or via current transmitted through forceps. Rarely, larger vessels are transected, and these should be ligated with suture. Care should also be taken to ensure that the incised edge down to the base of the excision remains perpendicular to the skin surface.

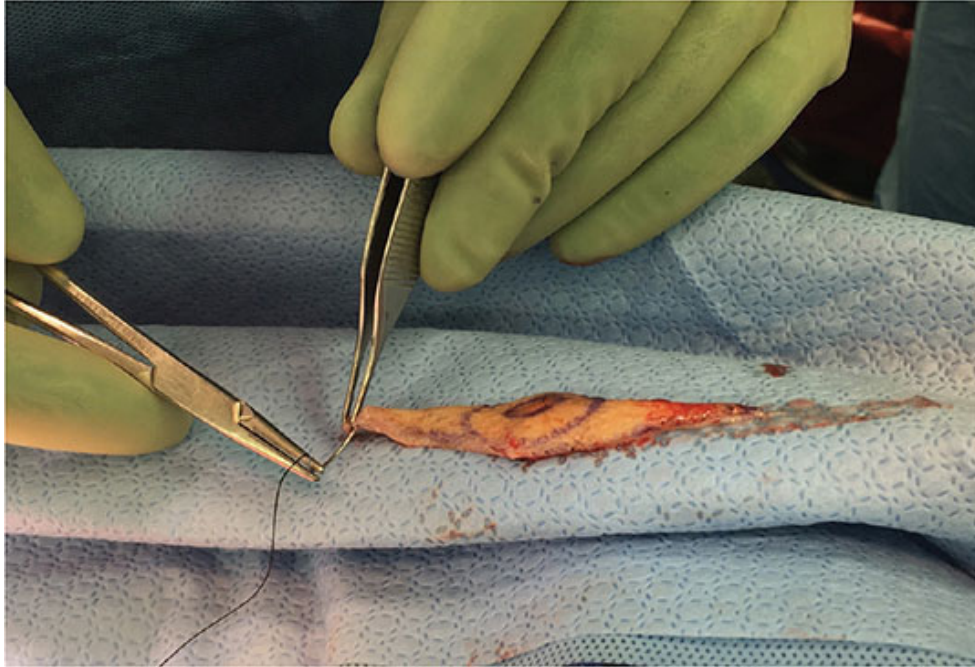


Figure 46-3. Placement of orienting suture on melanoma specimen for pathological evaluation.

Once hemostasis has been obtained, the wound should be assessed for closure. Most wounds are undermined ([Fig. 46-4](#)). Closure should proceed in layers. Fascial plication may be performed with 2-0 polyglactin 910 (Vicryl). Suture depth should be consistent along the entire length of the incision to prevent tissue bunching and abnormal surface contour. In the subcutaneous layer, tapered needles may be helpful because they do not cut through the fragile, fatty tissue. The next layer of suture involves the deep dermis, which may be closed with 3-0 polyglactin 910 on a tapered or reverse cutting needle. Similar principles of symmetry apply. The sutures are placed in a buried fashion so that the knot is on the underside of the stitch, which prevents exposure to the surface and reduces contour abnormalities on the skin. The sutures are placed in an interrupted manner that apposes the skin edges, approximately half a centimeter apart along the length of the excision. For a detailed discussion of suturing techniques, see [Chapter 13](#).

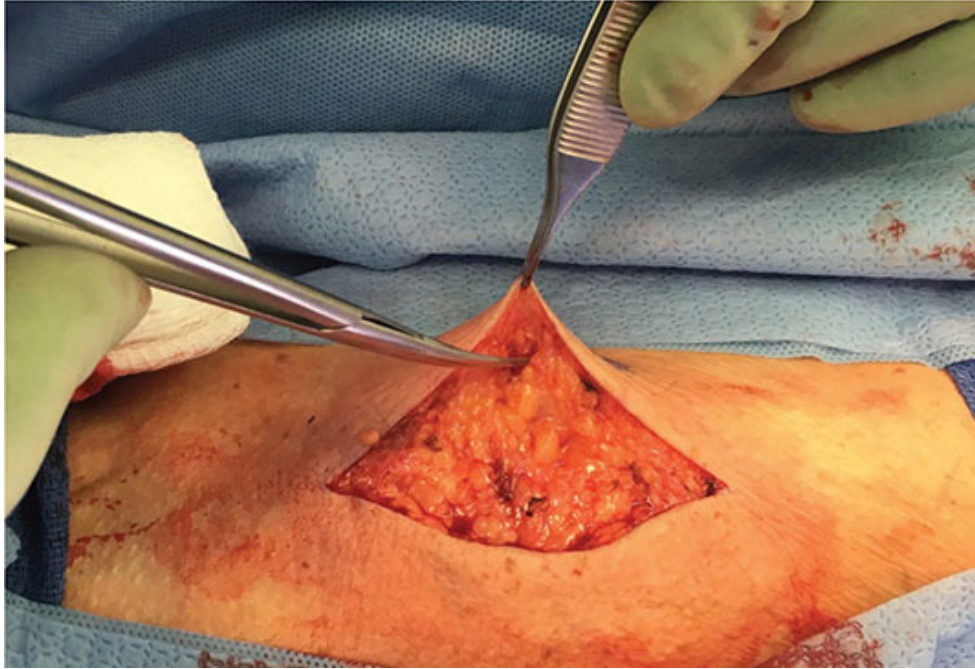


Figure 46-4. Creation of skin flaps with scissors to reduce tension on closure.

The final closure layer involves the superficial dermis and epidermis, which may be brought together in a subcuticular fashion using 4-0 polyglactin 910 on a cutting or reverse cutting needle. The skin should be held in line with the direction of the needle to prevent skiving or creating a “button hole,” when suture material comes through the surface of the skin. The wound is then washed and dressed (Fig. 46-5). Patients are allowed to shower with the dressing, but are instructed not to submerge the wound under water. Detailed postoperative instructions should be provided.



Figure 46-5. Completed closure of wide local excision for melanoma.

Width and depth recommendations for wide excision of melanoma

The primary melanoma depth of invasion determines the peripheral margin for WLE. Historically, melanoma was treated with excision margins of 3 to 5 cm, which was thought to be necessary to reduce local recurrence and improve survival. However, reports of comparable outcomes with smaller margins prompted a series of prospective randomized controlled trials over the last three decades that evaluated margin width. Multiple national study groups independently carried out these trials, which varied in range of melanoma depth evaluated, excision margin size, surgical technique, and outcome measures. The current NCCN recommendations for surgical margins are extrapolated from these multiple findings ([Table 46-4](#)).¹⁸

Table 46-4. NCCN Guidelines for Surgical Margins for Wide Excision of Primary Melanoma¹⁸

Breslow Depth (mm)	Recommended Clinical Margin (cm)
In situ	0.5–1.0
≤1.0	1.0
1.01–2.0	1.0–2.0
2.01–4.0	2.0
≥4.0	2.0

Three major trials studied surgical margins for melanomas less than 2 mm in depth. The Swedish Melanoma Group evaluated 989 patients with primary cutaneous melanoma of the trunk or proximal extremity that were 0.8 to 2 mm in depth, and were excised with either a 2- or 5-cm surgical margin. Endpoints included overall survival and recurrence free survival, and they found no significant difference between groups, therefore recommending a 2-cm surgical margin for lesions 0.8 to 2 mm in depth.¹⁹ Similarly, the French Group of Research on Malignant Melanoma evaluated 337 patients with primary cutaneous melanoma of the trunk or proximal extremity that were less than 2 mm in depth, and were excised with either a 2- or 5-cm surgical margin. Endpoints included disease-free survival and overall survival. No difference was found between groups, and the authors also recommended a surgical margin of 2 cm for melanomas less than 2 mm in depth.²⁰ A third trial by Veronesi et al. studied 612 patients with primary cutaneous melanoma of the trunk or extremity that were less than 2 mm in depth, and were excised with a 1- or 3-cm surgical margin. Endpoints included development of metastatic disease, disease-specific survival, and overall survival. They found no significant difference between groups in these endpoints. However, the 1-cm margin group had a slightly higher rate of local recurrence for lesions 1 to 2 mm in diameter. From these findings, the authors concluded that for melanomas thinner than 1 mm, a 1-cm margin is sufficient, and for lesions less than 2 mm in depth, there is no survival benefit with a larger excision margin.²¹

Based on the results from these trials, it was established that a 2-cm margin is sufficient for lesions less than 2 mm in depth, and a 1-cm margin is sufficient for lesions less than 1 mm in depth. However, there remains debate with regard to appropriate margin width for in situ lesions and melanomas 1

to 2 mm in depth. Regarding in situ lesions, NIH consensus guidelines from 1992 recommend a 5-mm margin, but multiple recent series suggest 5 mm may be inadequate for up to half of in situ lesions. Clearance rate ranges from 0% to 86% with 5-mm margins, but reaches 97% with approximately 9-mm margins.²²

For lesions 1 to 2 mm in depth, Hudson et al. reviewed 1,225 patients that underwent 1-cm versus 2-cm margin excision, and found a significantly increased rate of local recurrence in the 1-cm margin excisions, though no effect on overall survival.²³ These findings are commensurate with the results from the Veronesi et al. trial.²¹ The Australian and New Zealand Melanoma Trials group is currently evaluating 1-cm versus 2-cm wide excision margins for patients with melanoma greater than 1-mm thickness in a phase 3 clinical trial.²⁴ Additional high-risk prognostic markers including ulceration and mitoses may provide further insight regarding optimal margin width.²⁵

Appropriate surgical margins for thicker melanomas are better established. Three major trials evaluated melanomas greater than 2 mm in depth. The Intergroup Melanoma Surgical Trial studied 740 patients with primary cutaneous melanoma of the proximal and distal extremities, trunk, head, and neck that were 1 to 4 mm in depth, and were excised with either a 2- or 4-cm surgical margin. They found no significant difference in local recurrence or survival between groups and concluded that a 2-cm margin is safe for melanomas less than 4 mm in depth. They also observed that ulceration was the greatest determinant of local recurrence.²⁶ More recently, a large multicenter trial from the combined efforts of the Swedish and Danish Melanoma Groups evaluated 936 patients with melanoma of the trunk or extremity that were greater than 2 mm in depth, and were excised with either a 2- or 4-cm surgical margin. The primary endpoint was overall survival, and they found no significant difference between groups, recommending a 2-cm margin for lesions greater than 2 mm in depth.²⁷ Finally, the UK Melanoma Group performed a trial in which 900 patients with primary cutaneous melanoma of the trunk or proximal extremity that were greater than 2 mm in depth, and were excised with a 1- or 3-cm margin. The primary endpoint was disease-specific survival, and although they found no significant difference between groups, there was a trend toward worse

survival in the 1-cm group, prompting the authors to conclude that a 1-cm margin was inadequate for lesions greater than 2 mm in depth.²⁸

From these trials, it was established that for all melanomas greater than 2 mm in depth, a 2-cm surgical margin is sufficient. A summary of these trials including melanoma depth, margin width, and key results is shown in [Table 46-5](#).

Table 46-5. Randomized Controlled Trials Evaluating Melanoma Surgical Margins

Trial	Melanoma Depth Range Under Study (mm)	Excision Margins (cm)	Findings	Recommendation
Veronesi et al. ²¹	≤2	1 vs. 3	No difference in locoregional recurrence or survival	1-cm margin for lesions ≤1 mm in depth
Khayat et al. ²⁰	<2.1	2 vs. 5	No difference in locoregional recurrence or survival	2-cm margin for lesions <2.1 mm in depth
Cohn-Cedermark et al. ¹⁹	0.8–2	2 vs. 5	No difference in locoregional recurrence or survival	2-cm margin for lesions 0.8–2 mm in depth
Balch et al. ²⁶	1–4	2 vs. 4	No difference in locoregional recurrence or survival	2-cm margin for lesions 1–4 mm in depth
Gillgren et al. ²⁷	>2	2 vs. 4	No difference in locoregional recurrence or survival	2-cm margin for lesions >2 mm in depth
Hayes et al. ²⁸	>2	1 vs. 3	Trend toward worse survival in 1-cm excision group (HR 1.24)	1-cm margin inadequate for lesions >2 mm

HR, hazard ratio.

Unlike peripheral margin width for surgical excision of melanoma, there is a paucity of research evaluating the optimal depth of excision, which remains unknown. There are currently no consensus guidelines on melanoma depth of excision, specifically in relation to muscular fascia, and no randomized controlled trial data to guide management. For the majority of extremity and trunk melanomas, there is ample superficial soft tissue to obtain an excision depth of several centimeters. However, on distal extremities, the head, neck, and face encountering muscular fascia, and possibly incorporating fascia into the excision, is more relevant. Hunger et al. assessed 213 patients with melanoma greater than 2 mm in thickness, and found no survival benefit to excising the deep fascia in melanoma.²⁹ Grotz et al. evaluated 278 patients with melanoma greater than 1-mm thickness, and similarly found no survival benefit with excision of muscular fascia compared to dissection to the fascia.³⁰ In the United States, practice patterns are variable.³¹ The Mayo Clinic surveyed their surgeons, and found that approximately two-thirds dissect down to the muscular fascia, but do not

include it with the excision. Common practice is to dissect to muscular fascia without incorporating it into the melanoma excision.³²

Indications for sentinel lymph node biopsy

Morton et al. published the seminal work on SLNB in melanoma in 1992, providing a less invasive method for evaluating micrometastases in patients with normal regional nodes.³³ This technique provides accurate staging, prognostic and treatment-related information, and protects patients without nodal disease from unnecessary lymphadenectomy. SLNB technique is predicated on the finding that lymph channels draining to specific nodes can be identified and mapped, and the primary drainage node for a melanoma is most likely to harbor metastatic cells (Fig. 46-6). There is a less than 1% chance of other nodes having metastatic disease when the sentinel node is negative. Overall, SLNB has a false-negative rate of approximately 2% to 4%, either due to the surgeon not identifying the true sentinel node, nonsentinel node involvement, or missed pathologic findings.^{34,35} The learning curve associated with this technique was addressed in one study that demonstrated that operators need to perform 55 or more SNLB procedures to gain the skill required to reliably reduce nodal relapse.³⁶ Lymph node status as determined by SLNB is the most important prognostic factor predicting survival in cutaneous melanoma.³⁷

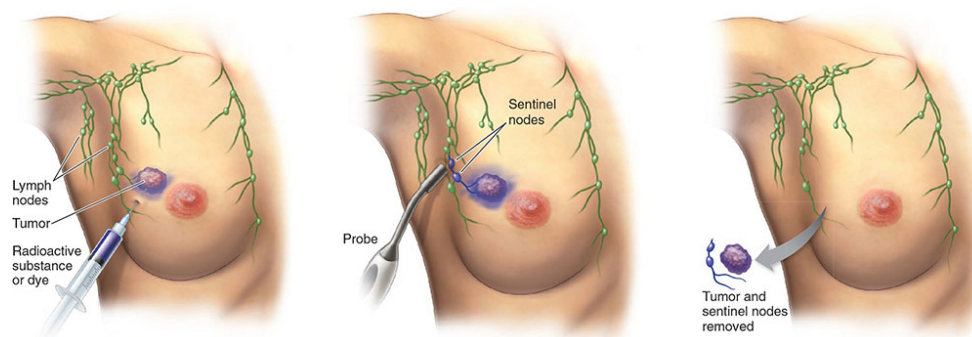


Figure 46-6. Sentinel lymph node biopsy schematic.

The Multicenter Selective Lymphadenectomy Trial (MSLT) prospectively evaluated SLNB with immediate lymph node dissection for positive micrometastases compared to observation for intermediate-thickness

melanoma (defined as 1.2–3.5 mm in thickness). For all patients, there was no overall or disease-specific survival difference between groups, but among those with nodal involvement, there was prognostic and survival benefit with node mapping and immediate lymphadenectomy. The frequency of micrometastases was 21.9% in the biopsy group, and nodal relapse occurred in 19.5% of patients in the observation group.³⁸ The observation group had nearly three times more positive nodes at ultimate nodal surgery, suggesting disease progression during the observation period, and the 5-year survival was significantly worse in patients with delayed lymphadenectomy ($p = 0.004$).³⁹ Ten-year follow-up of the MSLT confirmed these findings.³⁸ Interestingly, the MSLT showed no benefit for patients with thick melanomas (greater than 3.5 mm), suggesting immediate lymphadenectomy was not as important for this subgroup, which was also shown in prior studies evaluating elective lymph node dissection (ELND) versus observation.⁴⁰ Based on these and other trial findings, the American Society of Clinical Oncology (ASCO) and Society for Surgical Oncology (SSO) provided guidelines in 2012 for the use of SLNB in staging patients with newly diagnosed melanoma, recommending SNLB for all patients with intermediate-thickness melanoma (Breslow criteria, 1–4 mm), and immediate lymphadenectomy for patients with positive micrometastases. They found insufficient data to support routine SNLB for lesions less than 1 mm in thickness.⁴¹

Sentinel lymph node biopsy technique

Intraoperative node mapping is performed using a combination of vital blue dyes and radiopharmaceuticals with gamma probe detection. The most commonly used dyes are methylene blue and isosulfan blue, which are independently associated with a sentinel node detection rate of 82% to 95%.^{42,43} Comparison studies have shown no difference between dyes.^{44,45} Isosulfan blue costs more, is associated with urticaria or rash in 1% to 3% of patients, and has a 0.1% to 0.5% risk of anaphylactic reaction.⁴⁶ Methylene blue has a rare association with local skin necrosis following intradermal injection.⁴⁷ Dye is injected intradermally around the lesion or biopsy site. The rate of lymphatic migration to sentinel node is variable, requiring approximately 15 to 30 minutes in most cases, and depends on the location

and distance from the nodal basin (e.g., extremity vs. trunk, distal vs. proximal extremity). Soft-tissue lymphatics are concentrated in the dermis, and therefore intradermal injection theoretically provides optimal uptake. In general, the dye is injected in the operating room prior to incision, which provides sufficient time for nodal uptake.

Combined use of blue dye and radioisotope lymphoscintigraphy, typically technetium 99 (^{99m}Tc), improves the sentinel node detection rate from 98% to 99%.^{48,49} Radioisotope lymphoscintigraphy was pioneered in the 1970s, though application of intraoperative gamma probe detection appeared in the 1990s (Fig. 46-7).⁵⁰ ^{99m}Tc bound to colloid was found to be an effective agent due to its increased photon flux and absence of beta radiation. Multiple colloid agents with variable sizes and lymphatic passage rates have been studied, including albumin and sulfur colloid.⁵¹ Antimony sulfide is another effective compound for lymphatic mapping, but is not available in the United States. More recently, new techniques for radiolabeled molecular targeting of nodal tissue have been studied in a clinical trial setting; these agents may provide faster ejection site clearance, allowing for shorter lag time between injection and surgery, and potentially more accurate sentinel node radiolabeling.⁵² Radioisotopes are larger than dyes, and therefore require several hours to concentrate in the nodal basin. Therefore, patients are required to either undergo injection the night before surgery, or arrive several hours early on the same day.⁵¹ Uren et al. evaluated lymphatic flow rates in 198 patients with melanoma using ^{99m}Tc , and found mean flow (cm/min) to be lowest in the head or neck (1.5) and highest in the distal leg and foot (10.2). Rates were also higher for patients with residual inflammatory reaction after excisional biopsy.⁵³ As with dye, intradermal injection appears to be more effective than subcutaneous infiltration.⁵⁴ Importantly, ^{99m}Tc will remain concentrated in the sentinel node for up to 24 hours after injection, although its half-life for gamma emission is only 6 hours.

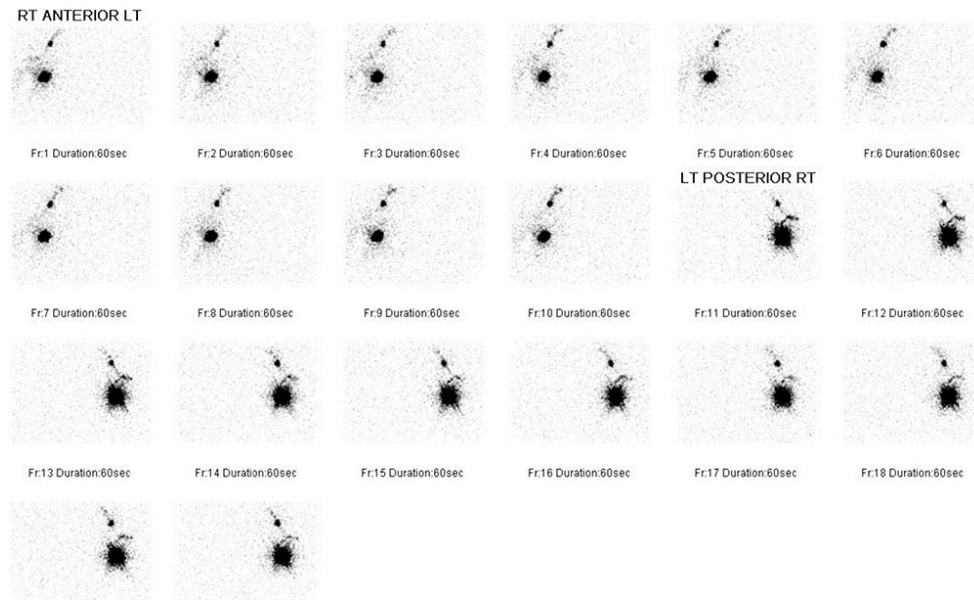


Figure 46-7. Lymphoscintigram.

Whereas upper and lower extremity melanomas reliably drain to the ipsilateral axillary and groin nodal basins, respectively, trunk melanomas more frequently drain to multiple or contralateral basins, which makes node staging and treatment challenging in these patients.^{55,56} Gordon et al. evaluated 859 patients with cutaneous melanoma, 465 located on the trunk and 394 on the extremities. Trunk melanomas were found to have significantly greater rates of multiple (31% vs. 7%) and contralateral sentinel nodes (25% vs. 1%). There was no difference in uncommon nodal occurrence between groups (7% vs. 8%), defined as nodes not located in the groin or axilla. Trunk melanomas were associated with significantly worse prognosis, consistent with multiple prior study findings.⁵⁵ Similarly, SLNB for head and neck melanoma (HNM) is technically more challenging, in part due to the presence of over 300 nodes in a confined area, and melanomas in this region often drain to multiple, contralateral and uncommon sites. In a review of over 3,400 HNMs, the sensitivity of SLNB by standard technique was 80% to 100%, with a false-negative rate up to 20%.^{57,58} Single-photon emission computed tomography (SPECT) and CT may provide added value regarding detection of sentinel nodes for HNMs.⁵⁹ Ultimately, SLNB is a complex procedure dependent on multiple factors. Some patients will have unexpected or irretrievable nodes. Effective technique relies on the

competence of and communication among nuclear medicine specialists, the surgeon, and the pathologist.

Morton et al. provided the first technical description of SLNB using 0.5 to 1 mL of vital blue or isosulfan dye injected intradermally around the lesion or biopsy site.³³ Although the principles have largely remained the same, the advent of radiocolloid has allowed for transcutaneous localization resulting in smaller incisions placed directly over a hot signal. Variables including tracer type, volume, injection site, waiting period, and surgeon experience have been extensively studied.

The procedure is performed as follows: Radiation technologists perform intradermal injection of ^{99m}Tc preoperatively, typically in sites immediately surrounding the biopsy scar, with an appropriate lag time for lymphatic migration to sentinel nodes. For operations that take place early in the morning, it may be necessary to inject the isotope in the evening prior to surgery. After anesthesia induction in the operating room, and prior to prepping and draping, the basins of interest are tested with the gamma probe for a hot signal. The point of maximal signal is marked for an incision. Next, blue dye is injected intradermally, and the tissue massaged. Both the site of WLE and SLNB are prepped in the same sterile field.

Prior to making an incision for the sentinel node biopsy, the gamma probe is again used to confirm the location of maximal signal. Patients undergoing axillary node biopsy or dissection should be asked about joint mobility or instability issues preoperatively. Local anesthetic is injected into the dermis to provide postoperative pain relief. The incision is ideally made along relaxed skin tension lines. Electrocautery or sharp dissection is used to dissect into the subcutaneous tissue, coagulating small vessels to ensure hemostasis. Once in the subcutaneous layer, dissection continues toward the node basin (Fig. 46-8). Constant testing of the surgical bed with the gamma probe helps focus the dissection in the appropriate direction of the sentinel node, limiting unnecessary tissue damage and lymphatic disruption. Mapping the migration of blue dye supplements this process. The advantages of a small incision include a better cosmetic result, reduced pain, and decreased risk of wound complication. However, this must be balanced against the difficulty of dissecting into a deep, fatty cavity, particularly within the axilla. Richardson retractors held by the assistant may help with exposure, and use of tonsil clamps to grasp the deep, fatty tissue provides improved visualization of the surgical bed. Metal clips may be applied to transected

tissue that appears to contain lymphatics or blood vessels to prevent lymphocele and postoperative bleeding.

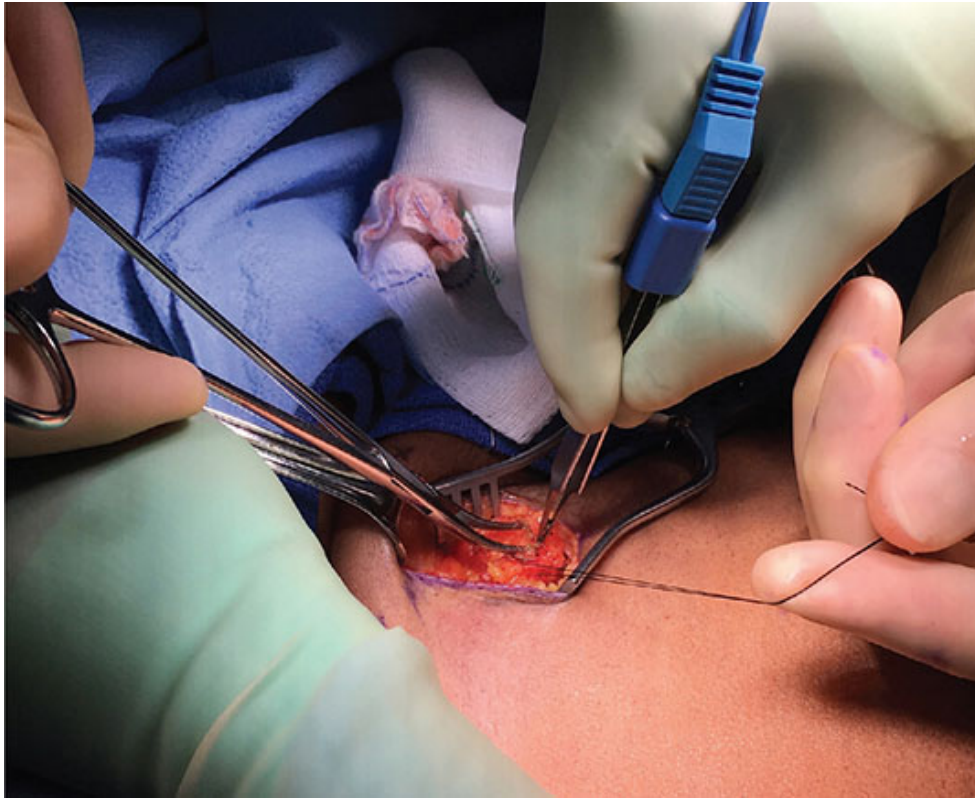


Figure 46-8. Dissection of sentinel lymph node for biopsy.

Each node typically has a vascular pedicle that bleeds with transection, which should be identified and clipped or cauterized as the plane along the capsule of the node is freed from the surrounding tissues. Care must be taken not to transect nodes in order to avoid potential oncologic compromise.

After the node is removed, node radioactivity is quantified with the gamma probe. The surgical bed is re-evaluated for hemostasis, and the probe is then re-inserted for identification of any remaining radioactive nodes. Nodes that have signal in greater than 10% of the sentinel node should be removed. It is important to note that if the tip of the probe is directed toward the primary lesion, a false-positive signal will occur from the very large amount of radiocolloid at the injection site. If the location of the primary tumor is anticipated to create this problem of “shine through,” the primary tumor should be excised as the first part of the procedure to eliminate the source of the radioactivity.

Ideal circumstances would permit accurate intraoperative histopathologic node analysis, preventing a second surgery for patients with positive nodal disease that require lymphadenectomy. However, the sensitivity of intraoperative imprint cytology and frozen section results remain relatively low for melanoma, in the range of 50% to 75%.⁶⁰ Given this finding, coupled with the low baseline prevalence of nodal metastases, routine intraoperative analysis is not typically recommended.⁶¹

INDICATIONS FOR LYMPHADENECTOMY

Prognosis for patients with regional metastatic disease is affected by multiple factors, including the number of nodes involved, whether the involvement is microscopic or macroscopic, and the presence of primary tumor ulceration.⁶² Of patients with clinically palpable nodal metastases, 70% to 90% will have distant metastases at presentation, and 5-year survival ranges from 6% to 40% in published series.^{63–65} There is little contention that regional lymphadenectomy is indicated for staging information, local disease control, and salvage in a subset of patients. Although there is no prospective clinical trial data evaluating survival outcomes with therapeutic lymph node dissection (TLND) for palpable disease, approximately one in five patients will attain 10-year survival, confirming that not all patients have occult distant disease, and thus regional eradication should be pursued.⁶⁶ This is particularly important given recent advances in medical oncologic approaches, as surgical nodal extirpation may provide the added benefit of tumor debulking.

For melanoma patients with microscopic nodal involvement, the application of lymphoscintigraphy and SLNB resulted in a paradigm shift in treatment. Prior to the advent of this technique, patients either underwent immediate ELND, or were observed for development of nodal disease. Several randomized controlled trials evaluating immediate versus delayed nodal dissection were performed in patients with normal regional nodes with mixed findings.^{67,68} Among patients with normal regional nodes, only 20% will have positive micrometastases on immunohistochemical analysis.⁶⁹ MSLT-I showed a disease-free and disease-specific survival advantage with immediate completion lymph node dissection (CLND) compared to

observation among patients with regional nodal disease, though it remains an ongoing question as to whether comparison only of node-positive patients in the two arms is valid.

In addition, it remains open to the question whether patients with positive SLNB benefit from CLND. Approximately 80% of patients with positive SLNB will not have additional metastatic nodal disease based on routine pathologic analysis of CLND specimens.⁷⁰ The DeCOG-SLT phase 3 trial attempted to further answer this question by randomizing patients with positive SLNB to either immediate CLND versus observation. The trial was stopped early and was underpowered, though no significant difference in distant-metastasis-free survival was found.⁷¹ The MSLT-II is ongoing and similarly randomizes patients with positive SLNB to observation versus CLND. The trial is slated to finish in 2022 and will hopefully have sufficient power to address this question. Thus, although CLND contributes to staging, its effect on regional disease control and overall survival are not definitively established.

Attempts have been made to predict nonsentinel node positivity based on clinicopathologic features in order to ascertain which patients with positive SLNB may benefit from CLND. Factors that have been shown to predict nonsentinel node involvement include SLN tumor burden, number of positive nodes, and primary lesion thickness and ulceration.^{70,72} In such settings, the NCCN recommends consideration of CLND in patients with positive SLNB.¹⁸

Technique for axillary lymph node dissection

Axillary dissection is performed under general anesthesia. Safe dissection involves knowledge of relevant anatomic borders (Table 46-6) and critical structures within the axilla, including the axillary vein, the thoracodorsal neurovascular bundle, and the long thoracic nerve (Fig. 46-9). The axillary nodes are divided into three levels. Level I includes all axillary nodal tissue lateral to the lower edge of the pectoralis minor. Level II nodes are located posterior to the pectoralis minor, and level III nodes are located medial to the pectoralis minor. The NCCN recommends 15 nodes be retrieved for adequate axillary dissection.¹⁸

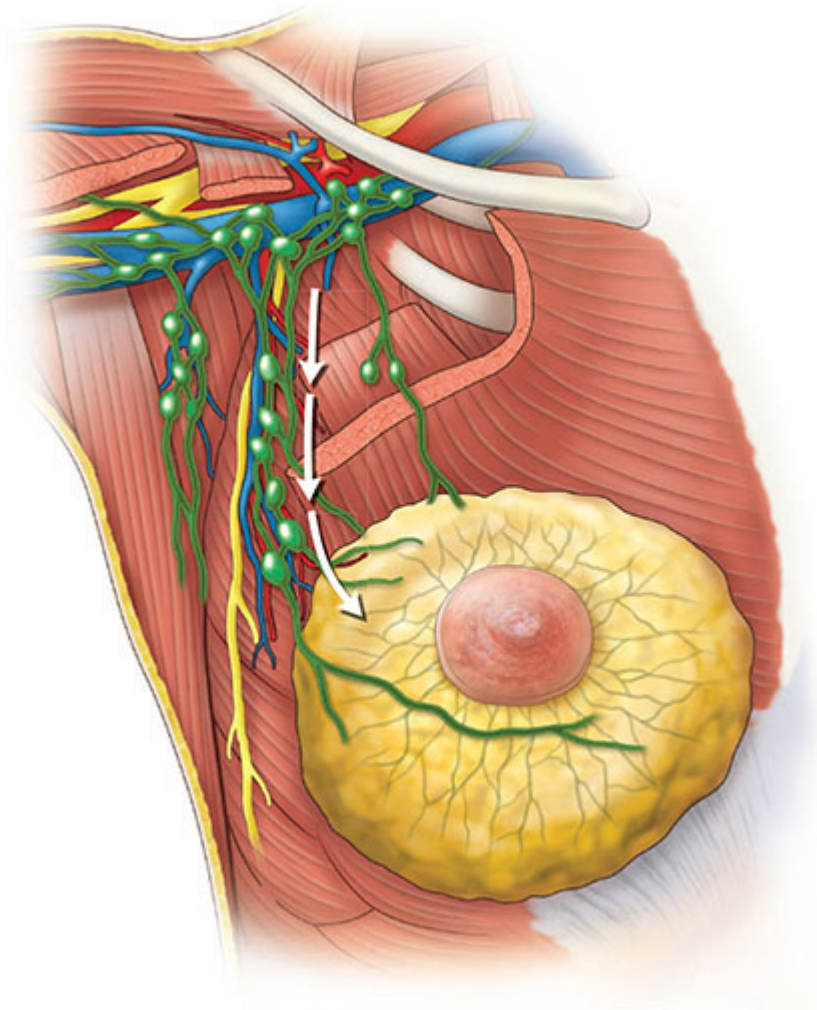


Figure 46-9. Axillary anatomy.

Table 46-6. Anatomic Borders of the Axilla

Surgical borders	■ Superior: axillary vein
	■ Medial: serratus anterior muscle and chest wall
	■ Lateral: axillary skin
	■ Anterior: pectoralis major muscle
	■ Posterior: latissimus dorsi muscle

A transverse incision in the axilla is generally utilized. The first portion of the procedure involves defining the borders of the axilla, including the pectoralis major, the latissimus dorsi, and the axillary vein. The critical neurovascular structures are then located and skeletonized, after which the

level I nodes can be dissected toward the pectoralis minor, followed by dissection of the level I node station (Fig. 46-10). For level III nodes, transection of the pectoralis minor is frequently necessary for adequate exposure, with limited functional consequence. A drain is placed at the end of the procedure, prior to layered closure. Postoperatively, arm compression or sling immobilization is not generally required, and patients should maintain range of motion to prevent shoulder joint contracture.

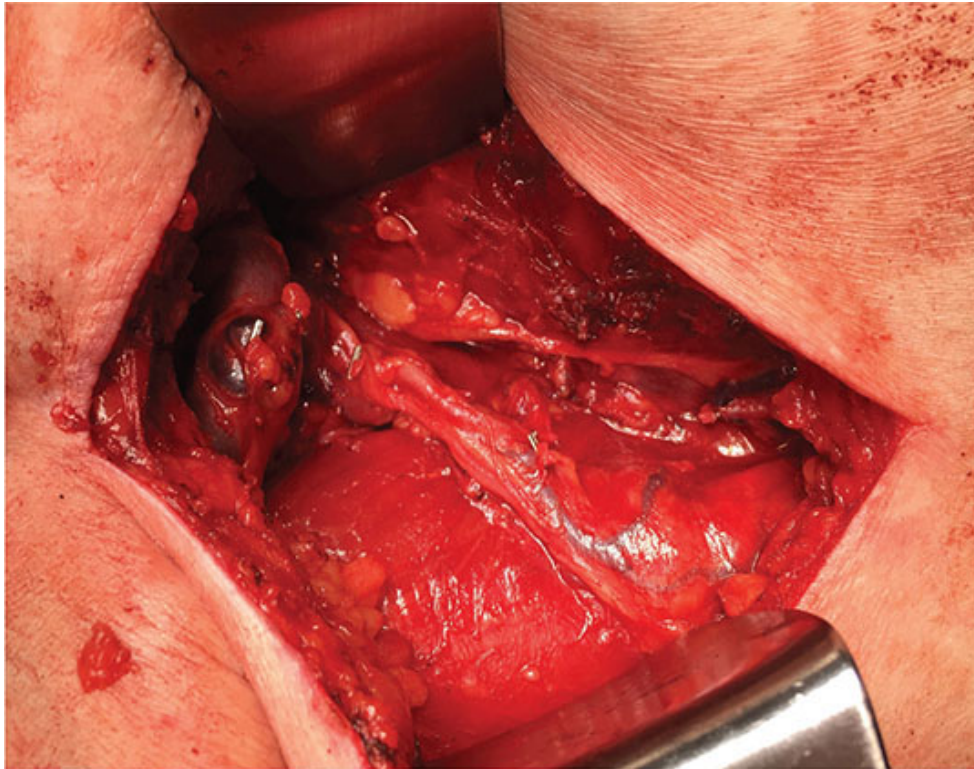


Figure 46-10. Skeletonized neurovascular structures after clearance of axillary nodal contents.

Complications from axillary dissection include wound infection and breakdown, hematoma, seroma, lymphedema, and nerve palsy; the overall complication rate is approximately 50%.⁷³ Seroma and wound infection are the most common short-term postoperative complications, which occur in up to 20% of patients.^{74–76} Reporting of lymphedema is variable based on definition, though it ranges from 10% to 20% in most series.^{77,78} A recent study found the use of ultrasonic scalpels for axillary dissection was associated with a significantly increased risk of lymphedema.⁷⁹ If

lymphedema is detected, treatment with arm elevation, exercise, and compression should be initiated.

Factors determining extent of groin dissection: superficial versus complete

The optimal extent of groin dissection is not firmly established for melanoma patients with lower extremity disease, particularly for those with clinical nodal involvement (stage IIIb). Superficial groin dissection (SGD) involves removal of inguinofemoral nodes, whereas complete groin dissection (CGD) is more invasive, including the obturator and iliac node basins. CGD is appropriate for clearing disease in patients with pelvic node involvement. Considerable effort has been made to predict which patients will have pelvic nodal metastases.

Factors that have been associated with pelvic lymph node disease include extracapsular extension (ECE), positive Cloquet's node, and large tumor burden on SGD.^{80,81} Oude Ophuis et al. showed in their series of 209 patients that underwent CGD that a combination of negative axial imaging, low lymph node ratio (LNR), low positive number of inguinal nodes, and no evidence of ECE demonstrated a negative predictive value (NPV) for pelvic node involvement of 84%.⁸⁰ CT and MR axial imaging modalities alone have shown variable results in predicting pelvic nodal involvement, with NPVs ranging from 40% to 86%.^{82,83} The sensitivity of a positive Cloquet's node in predicting pelvic nodal involvement is approximately 50%.^{84,85}

Among patients with clinically palpable groin nodes, approximately 25% to 35% will have deep pelvic node involvement.^{18,80} Pelvic node disease is associated with markedly worse prognosis. van der Ploeg et al. reviewed 169 patients with palpable groin metastases, and found that patients with pelvic lymph node invasion had a significantly worse 5-year overall survival of 12%, compared to 40% for patients without pelvic disease.⁸⁶ Consistent with this finding, Bastiaannet et al. found that 27% of patients with clinical nodal disease will have distant metastases discoverable by CT or PET, making regional surgery for these patients palliative in nature.⁸⁷ Interestingly, up to 17% of patients with microscopic disease will also have pelvic node involvement. In this subset of patients, LNR less than 0.1 and negative

Cloquet's node status were shown to each have an NPV of 95%, with error rates of 1.7% and 3%, respectively.⁸²

Importantly, for patients with either microscopic or macroscopic groin involvement, but without clinical or radiographic evidence of pelvic node involvement, there is no survival benefit, either disease-free or overall, with CGD compared to SGD.⁸⁸ Therefore, it is a reasonable approach for these patients to pursue axial imaging followed by SGD. For patients subsequently found to be high risk for pelvic nodal disease based on SGD results, progression to obturator and iliac dissection would follow. Although it is suboptimal for these patients to undergo two surgeries, this approach may prevent a majority of unnecessary CGDs.

In keeping with these findings, the NCCN guidelines recommend CGD as the standard of care for patients with CT or MR evidence of deep pelvic nodal involvement or positive Cloquet's node. The NCCN recommends consideration of CGD for patients with clinically palpable nodal disease, or greater than three involved nodes found on SGD.¹⁸

Technique for superficial and complete groin dissections

For groin lymphadenectomy, patients are given general anesthesia and positioned supine on the operating table. The anatomic borders of the femoral triangle include the inguinal ligament superiorly, the sartorius laterally, and the pubic tubercle and adductor longus medially. The confluence of the sartorius and adductor longus represents the inferior border (Fig. 46-11). The superficial node basin is found above the fascia lata, which overlies the musculature of this region. The nodes are categorized based on the location in the groin, including superolateral, superomedial, and inferior. SGD may be performed with a transverse or vertical incision (Fig. 46-12). The dissection in the femoral triangle extends to the anatomic borders with removal of nodal tissue (Figs. 46-13 and Fig. 46-14). If there is palpable involvement of superficial nodes, or involvement of Cloquet's node, progression to CGD is recommended. Lymph node bearing fat of the lower abdominal wall superior to the inguinal ligament is also resected as part of an SGD (Fig. 46-15).

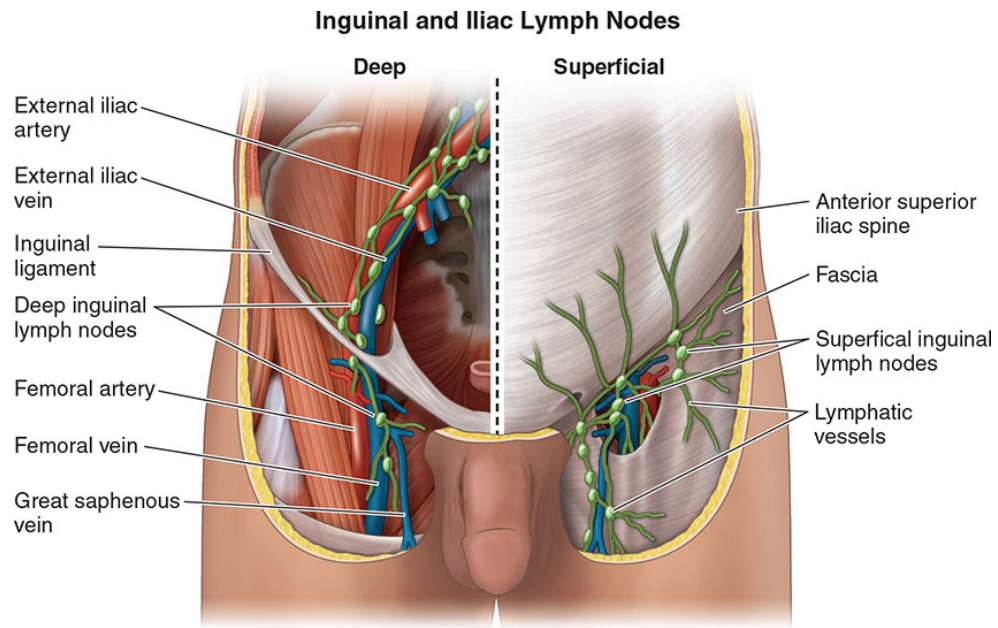


Figure 46-11. Groin anatomy.

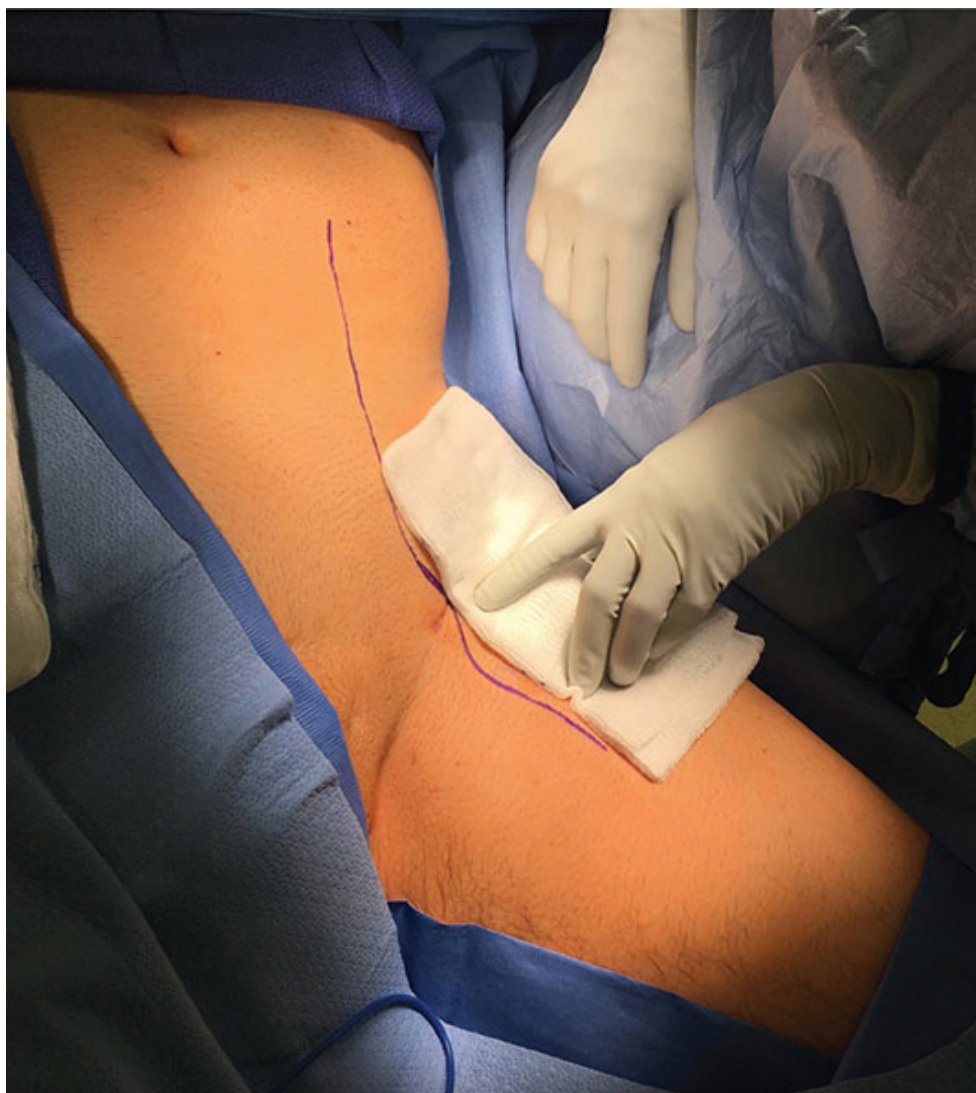


Figure 46-12. Groin dissection field prepped and draped, incision marked.

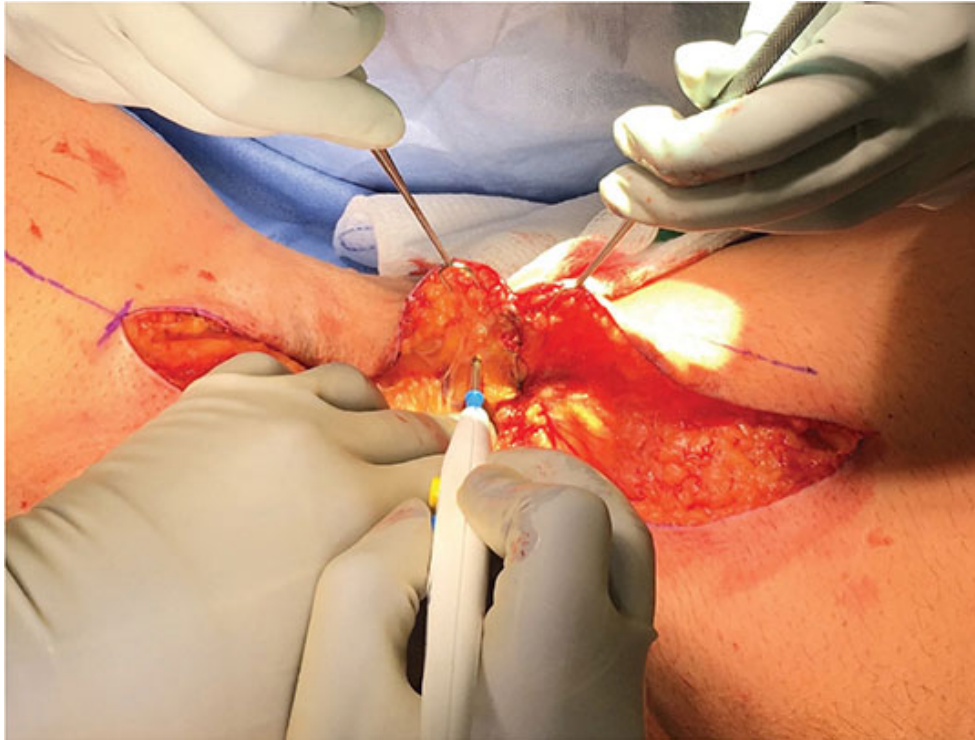


Figure 46-13. Creating skin flaps for superficial groin dissection.

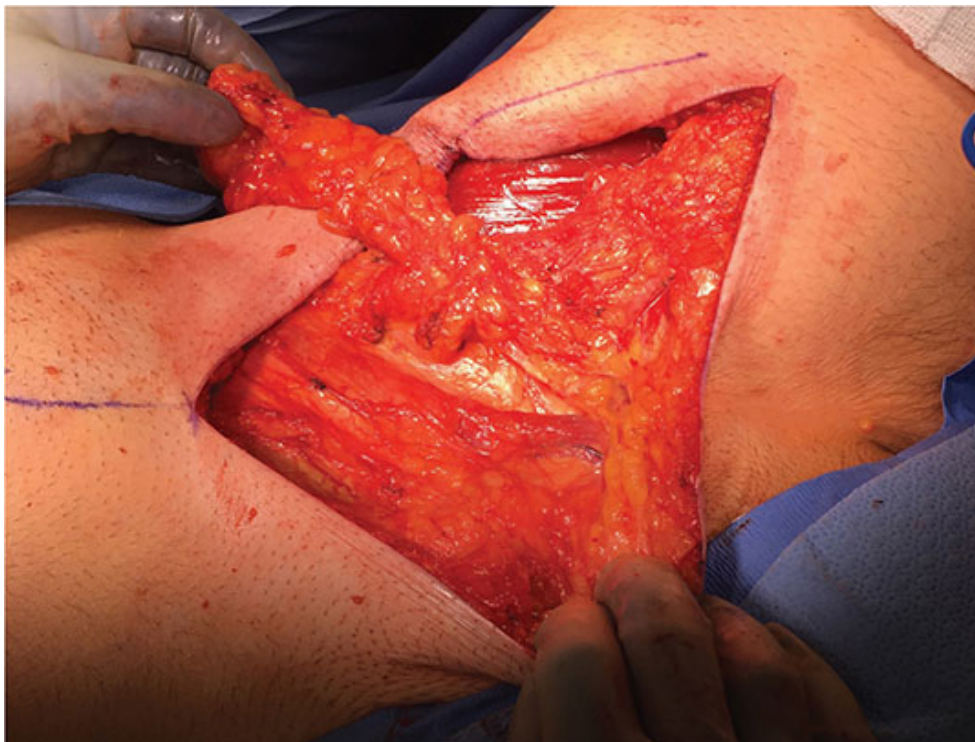


Figure 46-14. Superficial groin dissection of the nodal packet prior to extirpation.

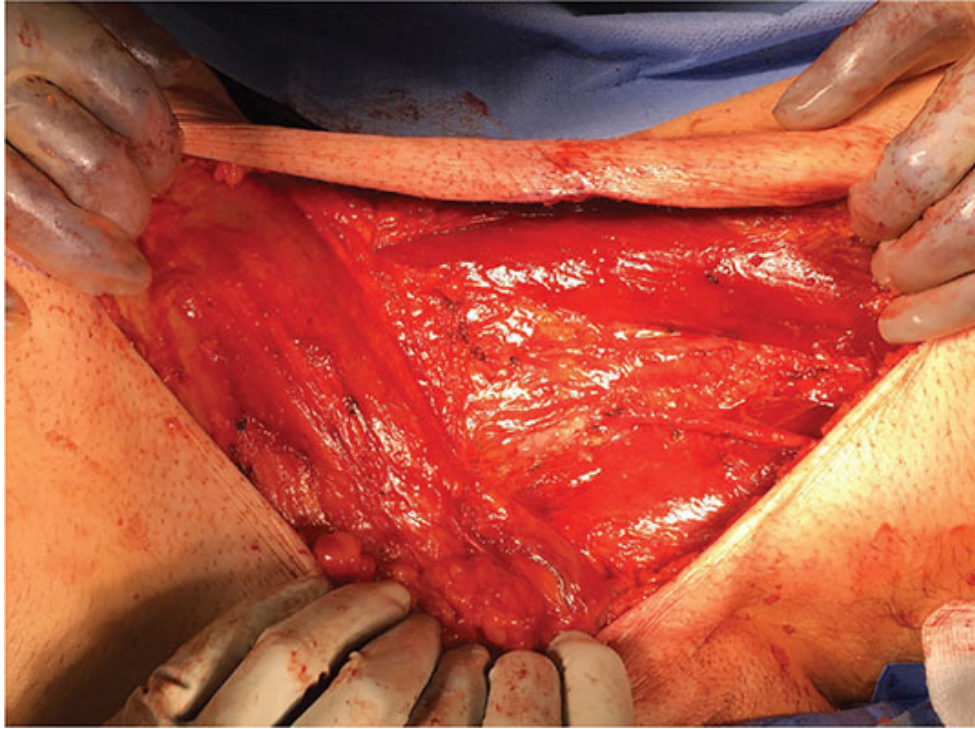


Figure 46-15. Groin anatomy after removal of superficial groin nodes.

CGD may be performed by extending a vertical incision above the inguinal ligament, or by making a separate transverse incision. To enter the retroperitoneal space, a curvilinear incision is made through the anterolateral abdominal wall musculature, and dissection is bluntly continued to the iliac vessels. The inferior epigastric vessels may be ligated for better exposure. The iliac nodes are dissected free in an inferior-to-superior fashion, terminating at the common iliac artery bifurcation (Fig. 46-16). However, the dissection may be extended to the aortic bifurcation if the disease is present along the common iliac vessels. The obturator node basin can be found inferomedially. The completion of CGD should include three node packets for pathologic evaluation: inguinofemoral, iliac, and obturator. The NCCN recommends 10 or more nodes retrieved for groin dissection.¹⁸ A sartorius muscle transposition flap may be created to protect the femoral neurovascular bundle prior to closure.⁸⁹ For both SGD and CGD, a drain is placed prior to closure (Fig. 46-17).

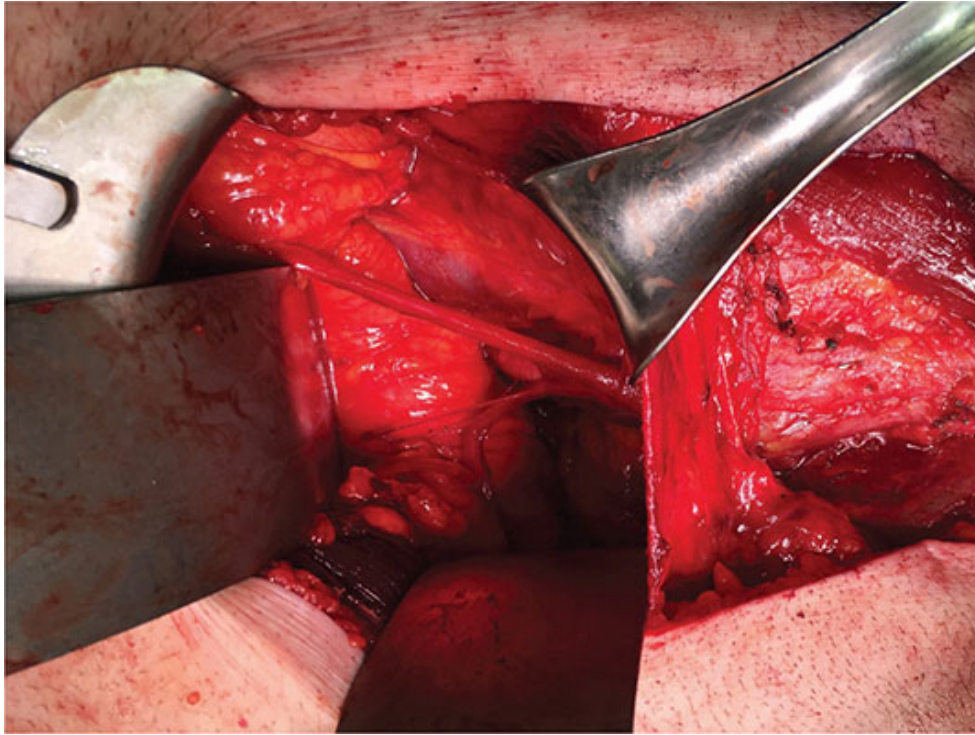


Figure 46-16. Retroperitoneal exposure with iliac vessel dissection for complete groin lymphadenectomy.

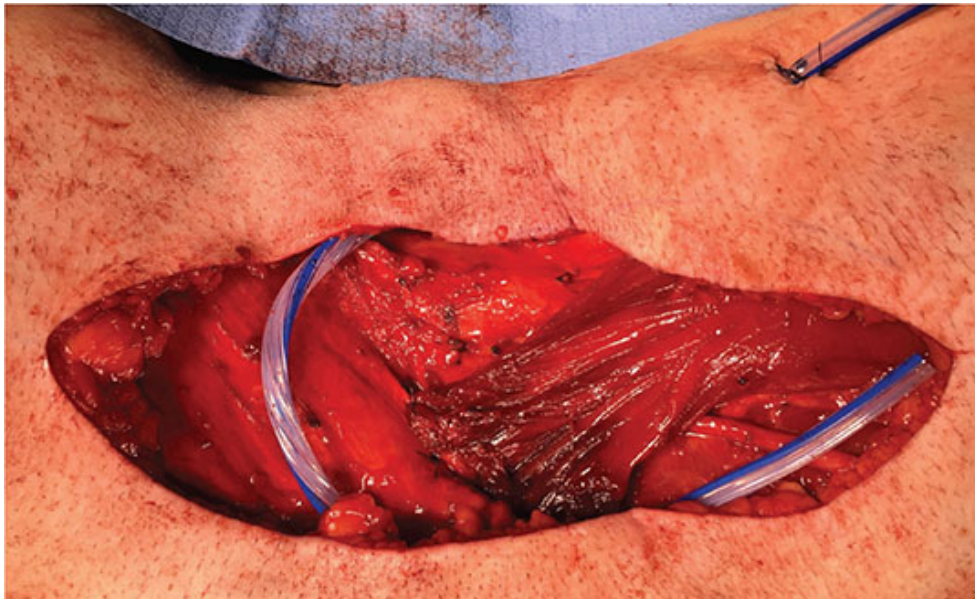


Figure 46-17. Sartorius flap creation to protect the femoral vessels prior to closure with drain placement.

Groin dissection is a morbid procedure with high complication rate, ranging from 20% to 90% in the reported literature, with most studies finding a rate of approximately 50%.⁹⁰ Complications include delayed wound healing and infection, seroma, lymphedema, and neurologic injury. Approximately 25% of patients will develop postoperative lymphedema in the ipsilateral extremity, of which 10% will result in a functional deficit.⁷⁵ Techniques for minimally invasive SGD and CGD have been developed as a strategy to reduce side effects and complications.

Technique for neck dissection

HNM accounts for up to 25% of all cutaneous melanomas.⁹¹ HNM occurs more often in elderly patients, and lesions are more commonly located on the face rather than the scalp, ears, or neck.⁹² Limited tissue domain, dense arrangement of critical neurovascular structures, and cosmetic considerations in the head and neck region present unique challenges for primary melanoma excision and lymphadenectomy.

Head and neck lymphatics drain in several patterns that are clinically relevant. Lesions of the face and anterior neck often metastasize to the facial, submandibular, and anterior cervical nodes. Lesions located on the posterior scalp and neck frequently drain to the periauricular, posterior occipital, and posterior cervical nodes, while lesions of the anterior scalp, including the forehead, frequently metastasize to the parotid and upper cervical nodes.⁹³ Approximately 25% of HNM nodal metastases are found in the parotid gland, for which parotidectomy with cervical lymphadenectomy should be considered, as 27% patients with parotid involvement will harbor positive nodes in the neck.⁹⁴ Lymphatic drainage from the ear is variable, but most often includes the periauricular, postauricular, and superior cervical node basins.

De Rosa et al. performed a systemic review of SLNB for HNM in 3,442 patients, and found that 15% had positive SLNs. At dissection, 13.7% of patients were found to have additional positive nodal metastases.⁵⁸ Neck dissection is currently recommended for patients with known parotid or nodal involvement, and the extent of dissection depends on the disease burden. Martin et al. evaluated their management of 716 patients with cervical lymph node metastases, and found no difference in recurrence

between radical, modified radical, and selective neck dissections.⁹⁵ In general, removal of all levels containing SLNs, as well as second tier levels that are at risk for harboring occult disease, should be considered. Preservation of the sternocleidomastoid, internal jugular, and accessory nerve is nearly always feasible.

Hyperthermic isolated limb perfusion for extremity melanoma

Hyperthermic isolated limb perfusion (HILP) is a surgical procedure that allows for local delivery of highly concentrated chemotherapeutic agents (up to 20 times that achieved with systemic therapy) to an extremity, avoiding generalized toxicity.^{96,97} Hyperthermia (40–43°C) is independently cytotoxic to cancer cells, and has been shown to reduce tumor burden in melanoma.^{98,99} Combination of the two is thought to have a synergistic cell-killing effect. HILP may be considered in patients with inoperable extremity melanoma, including primary, recurrent, or satellite lesions, but is more commonly utilized for in-transit metastases that are either too extensive for WLE, or are recurrent in nature. HILP has no prophylactic role, and is recommended only for therapeutic use in the presence of known disease.¹⁰⁰

HILP is predicated on circulatory isolation of the affected extremity with extracorporeal oxygenation and perfusion, which requires arterial and venous access with large-bore cannulation under direct vision. A proximal tourniquet is placed to limit leakage through the venous system. For the leg, cannulation of the external iliac artery and vein are most common, and for the upper extremity, the axillary artery and vein. Complete vascular isolation of the extremity is critical to prevent systemic toxicity. Therefore large branch vessels of the artery and vein must either be ligated and transected, or transiently occluded with vessel loops or vascular clamps. Once the cannulae are inserted into the vessels by the surgeon, they are connected to an extracorporeal oxygenation perfusion machine, which is composed of a volume reservoir, oxygenator, heat exchanger, and pump. The extremity temperature is monitored with percutaneous thermistors, and there are multiple methods for monitoring systemic chemotherapy leakage, including use of radiolabeled ^{99m}Tc, iodine 131, and dye dilution techniques.^{101–103}

Leak rate greater than 10% should warrant consideration of stopping the perfusion.¹⁰⁴

Heated melphalan (L-phenylalanine mustard) has been shown to be effective in clinical trials.^{100,105,106} Treatment response rates reported in the literature are variable. Complete response occurs in approximately 25% to 50% of patients, whereas partial response is seen in about two-thirds of patients.^{107–110} Multiple other agents have also been studied, some in combination, including TNF α , IFN γ , actinomycin, vincristine, cisplatin, fotemustine, and interleukin-2.^{111,112} However, these agents did not provide better outcomes, and only melphalan is currently used in the United States for HILP.

Regional toxicity from HILP may include extremity edema, erythema, and blistering. Occasionally, patients may develop neuropathy, joint stiffness, and immobility, though vascular complications and compartment syndrome are rare.¹¹³ Arterial thrombosis at the arteriotomy site occurs in up to 2% of patients.¹¹⁴ Importantly, more severe regional toxicity is not associated with improved outcomes.¹¹⁵ Signs of systemic toxicity include gastrointestinal upset including nausea, vomiting, and diarrhea. Postoperatively, patients should be monitored closely for signs of extremity swelling, and should undergo serial neurovascular examinations and evaluation for signs of systemic toxicity.

Isolated limb infusion for extremity melanoma

Isolated limb infusion (ILI) is a less invasive alternative to HILP with similar treatment principles for locoregional disease. In ILI, chemotherapy is infused into the affected limb at a slower rate under hypoxic, acidotic, and hyperthermic conditions. Access is obtained via percutaneous small-bore catheters in the uninvolved extremity. The cannulae are navigated across the midline to the affected limb under fluoroscopic guidance.¹¹⁶ Melphalan is manually infused for 30 minutes under tourniquet isolation while the extremity is monitored with percutaneous thermistors. The indications for ILI are similar to HILP.¹¹⁷

ILI has a lower risk of systemic toxicity than HILP, though has a similar risk profile for locoregional toxicity, including leg edema, erythema or

blistering, neuropathy, and rarely, compartment syndrome.¹¹⁸ Because of its reduced operative time and percutaneous approach (rather than surgical groin dissection), ILI provides a less invasive alternative than HILP for patients with comorbid conditions. In addition, ILI is a repeatable procedure, and may be offered as a salvage therapy for treatment failure or recurrent disease.

The primary drawback of ILI is that the treatment response rate with ILI is lower than HILP. Raymond et al. reviewed their experience of ILI and HILP in 188 patients (126 ILI, 62 HILP). HILP was associated with an overall response rate of 81%, and a complete response rate of 55%, whereas the overall and complete response rates for ILI were 43% and 30%, respectively.¹¹⁰ ILI is also associated with both a higher rate of recurrence and shorter time to recurrence than HILP.¹⁰⁹ However, there is no significant difference in overall survival between treatment types. Currently a new chemotherapeutic agent, temozolomide (TMZ), is in clinical trial for ILI therapy in melanoma. TMZ may have a lower toxicity profile, which would be advantageous for repeated treatments, though response rate in humans is still under study.¹⁰⁹

Surgical treatment of metastatic melanoma

Distant metastatic melanoma (stage IV) indicates hematogenous spread and is associated with a 10-year survival of less than 10%.¹¹⁹ Surgery for metastatic disease is provided for palliation of life-threatening complications, or for curative intent. Common palliative indications include resection of brain metastases, resection of bowel metastases to relieve gastrointestinal obstruction, and treatment of regional disease that may be causing chronic pain or open wounds. Metastatic melanoma can present variably, ranging from rapid, diffusely disseminated disease in some patients to indolent oligometastases confined to a specific region in others. The mechanisms, both genetic and immunologic, underlying these different presentations are poorly understood. However, in select patients with slowly progressing oligometastatic disease, there is potential that eradication of metastases will provide a survival benefit. Surgical resection offers long-term survival for a subset of patients with stage IV disease, with 5-year survival rates of 15% to 30%.^{120,121} The Malignant Melanoma Active

Immunotherapy Trial (MMAIT) is commonly cited in support of metastasectomy. In this trial, patients with stage IV disease underwent complete surgical resection of metastases, followed by randomization for treatment with vaccine therapy. In both arms, the 5-year survival was at least 40%, markedly higher than any other phase III trial for stage IV disease, which has been attributed to surgical eradication of distant disease.¹²² Other trials provide evidence in favor of treating metastatic disease for select patients with the potential for eradication. In the Southwest Oncology Group trial (SWOG S9430), among patients who underwent complete resection, median survival was markedly increased to 21 months.¹²³

For staging purposes, melanoma metastases are placed into three categories depending on the location: M1a, M1b, and M1c. M1a represents metastasis to soft tissue and distant nodes, M1b is metastasis to the lungs, and M1c represents visceral metastasis or any distant metastasis associated with an elevated lactate dehydrogenase (LDH) level. Skin and subcutaneous tissue metastases are associated with the best prognosis, followed by distant nodes, and surgical eradication of M1a disease may increase median survival up to 60 months based on retrospective analysis of MSLT-1 data.¹²⁴ Skin, subcutaneous, and nodal metastases are generally detected earlier by the nature of their location, which may contribute to the improved survival of this category. Metastases to the lungs are frequently asymptomatic, and incidentally discovered on surveillance CT imaging. M1b disease is associated with a 1-year survival of 57%. Similarly, visceral metastases are often asymptomatic, though may manifest as gastrointestinal discomfort, obstruction or elevated liver serum markers. M1c disease is associated with the worst 1-year survival at 45%.¹¹⁹ Features of metastases based upon location are described in [Table 46-7](#).

Table 46-7. Common Locations and Features of Melanoma Metastases

Location	Characteristics
Skin and soft tissue	■ Recommend resection to grossly negative margins ■ Hyperthermic isolated limb perfusion or isolated limb infusion may help treat in-transit metastases and diffuse locoregional recurrence ■ Associated with best long-term survival among metastatic locations ■ Detected early by visual inspection or palpation
Lymph node	■ Recommend complete node dissection for the basin containing the metastatic node ■ Survival after extirpation better than for pulmonary or visceral disease ■ Detected early by visual inspection or palpation
Pulmonary	■ Most common site of melanoma metastases (40%) ■ Frequently asymptomatic, detection usually made by surveillance CT imaging of the chest ■ Tumor doubling time (monitored by serial chest x-ray) greater than 60 days associated with improved prognosis after surgical eradication¹²⁵ ■ Fewer nodules and prolonged disease-free interval associated with better prognosis
Intestinal	■ Often presents as disseminated disease with multiple foci ■ May be symptomatic presenting with bleeding, abdominal pain, or obstruction ■ Small bowel is the most common site of metastasis of the gastrointestinal tract (70%) ■ Melanoma invades bowel serosa, and may cause intussusception ■ Complete eradication through resection of involved bowel may improve survival in select patients
Liver	■ Associated with very poor prognosis ■ Capsule stretch may present as abdominal pain ■ Detection frequently based on abnormal CT surveillance imaging or liver enzyme abnormality ■ Hepatic resection typically not indicated except in rare cases ■ For unresectable disease, radiofrequency ablation and cryoablation are alternatives options ■ Capsule rupture is a rare but potentially catastrophic complication
Brain	■ Typically presents as multifocal disease ■ Surgery can be helpful for treatment of large masses ■ Whole brain radiation enhances survival after surgical resection ■ Stereotactic radiosurgery is an alternative for patients with multiple metastases ■ Fewer lesions and prolonged disease-free interval associated with improved prognosis

Appropriate patient selection for surgery remains an ongoing challenge for stage IV disease. Martinez et al. propose a set of qualification criteria: good functional status, life expectancy greater than 3 months, less than two separate visceral sites, and less than eight total metastases.¹²⁶ Multiple other groups have put forth proposals with similar criteria. An important distinction is that complete metastasectomy provides superior survival outcomes compared to cytoreductive surgery.¹²⁷ The decision to provide palliative surgery can be more challenging. Patients with pain, bleeding, or other symptoms such as gastrointestinal obstruction can often be effectively treated, though first requires careful consideration of multiple factors including projected survival, functional status, goals of care, and capacity to heal.

CONCLUSIONS

There have been great advances in the surgical management of melanoma over the last four decades, with marked improvement in survival for local and regional disease. Surgical techniques including biopsy, wide excision, sentinel node biopsy, lymphadenectomy, and isolated limb perfusion have

been largely optimized from an operative standpoint, but the appropriate application of these procedures is an area of ongoing investigation. In the modern era, there still remain basic unanswered questions, including the appropriate selection of patients for node sampling with thin melanoma, the value of CLND in clinically node-negative patients with positive sentinel nodes, and the appropriate selection of patients for resection of distant metastases. Going forward, advances in our understanding of melanoma biology will potentially allow for personalized surgical management of similarly staged lesions. Improved systemic therapies will likely reduce the need for morbid procedures including lymphadenectomy and metastasectomy. Finally, as more information about molecular, genetic and histopathological features of melanoma are applied to treatment and prognostication, collaboration between surgical and medical fields will be essential for effective application of this information to individualized care.

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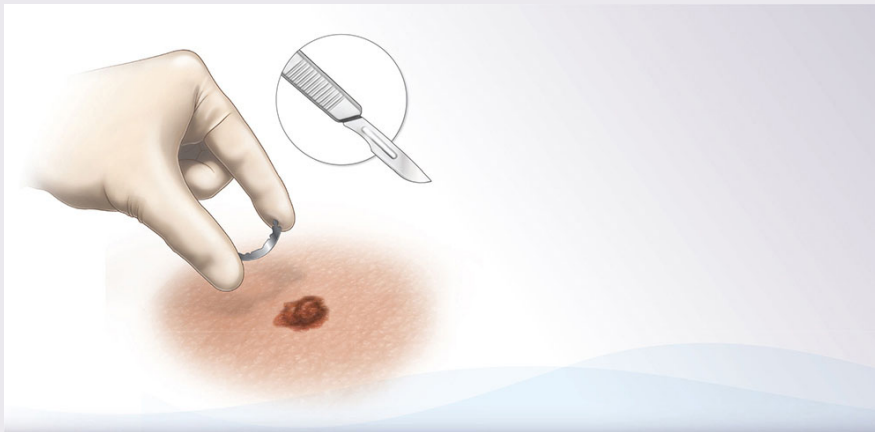
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CHAPTER 47 Dysplastic Nevi

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SUMMARY

- CAN and DN are clinicopathologic markers of patients at an increased risk for melanoma. Patients with CAN/DN should be screened regularly for melanoma.
- CAN are not obligate precursors to melanoma, and they do not have to be removed—they may be clinically monitored for change.
- The majority of melanomas are believed to arise de novo, and are not associated with a precursor nevus.

Beginner Tips



- A biopsy of a pigmented lesion is performed if there is a high level of suspicion for melanoma. Other reasons for biopsy may include irritation, cosmesis, or atypical lesions in areas difficult to self-monitor.
- An excisional biopsy is the preferred method to remove any lesion concerning for melanoma to provide the most accurate diagnosis and smallest risk of recurrence.

Expert Tips



- Reexcisions need not be performed in mildly and moderately DN with clear margins on the original biopsy.
- Mildly DN with positive histologic margins and no clinical residual pigmentation can be safely observed.

Don't Forget!



- Observation of moderately DN with positive histologic margins and no clinical residuum may be reasonable, but more data are needed.
- Severely DN with positive histologic margins should be reexcised.

Pitfalls and Cautions



- While the morbidity of a biopsy should always be considered, there is no substitute for biopsy in cases where a true concern for evolving melanoma exists.
- Serial photography has no impact on the development of melanoma unless the clinician has a low threshold for biopsy for any evolving CAN.

Patient Education Points



- Patients should be taught that all CAN do not evolve on to melanoma, and that they represent a marker of melanoma risk rather than a “precancer.”
- Therefore, most CAN may be monitored clinically as long as there is no evolution and they appear similar to the patient’s other CAN.

Billing Pearls



- The decision of whether to code a shave as a biopsy or shave removal is based on the surgeon's intent. Even a deep, broad scoop shave, if performed to *biopsy* the lesion in question, should be coded as a biopsy.

CHAPTER 47 Dysplastic Nevus

INTRODUCTION

Clinically atypical nevus (CAN)/dysplastic nevus (DN) are a subset of melanocytic nevus that clinically have an irregular, poorly defined border, asymmetric shape, and variegated pigmentation, and are generally larger than 5 mm.¹ When biopsied, these lesions have certain histologic findings including disorganized melanocytic proliferations and associated atypical cells.² Although CAN/DN themselves are not obligate precursors to melanoma, they are clinicopathologic markers of patients with an increased risk for melanoma.^{3,4} Some patients that have numerous CAN/DN can be challenging to follow clinically and may require surgical procedures for lesions suspicious for melanoma.

BACKGROUND

William Norris, a Scottish surgeon, reported the first case of cutaneous melanoma in 1820. He also observed high numbers of nevus on his patient, and proposed that the two conditions may be related.⁵ In the 1970s, CAN/DN were described among individuals from melanoma-prone families. In 1978, Clark and colleagues described CAN/DN as part of the “B-K mole syndrome” (named for two patients in the study) among patients from families affected by familial malignant melanoma (FMM).⁶ Around the same time, Lynch’s group described four individuals in a melanoma-prone family, and found three of them to have a larger number of CAN (>200).⁷ In 1980, Elder et al. proposed the term “dysplastic nevus” for these morphologically atypical moles with irregular outlines and pigmentation that tended to occur more commonly on sun-protected areas when compared with common or

banal nevi (CN) and had histologic evidence of dysplasia.⁸ The National Institutes of Health (NIH) held a consensus meeting to further define the histologic criteria for DN in 1992 and recommended the clinical term “atypical nevus” versus the pathologic term, “nevus with architectural disorder.”⁹

PATHOPHYSIOLOGY

Several genetic alterations have been implicated in the development of DN. For example, mutations in a cell cycle regulator, p16INK4a appear to be involved in tumorigenesis and in DN.¹⁰ Carriers of p16 mutations are more likely to have greater than 100 nevi, according to a study by Bishop et al. of five families with these mutations.¹¹ Other alterations in BRAF, NRAS, and mismatch repair enzymes are also present in DN, but these mutations can also be found in both melanoma and CN.^{10,12–15} When gene expression patterns were examined by Scatolini et al. among CN, DN, and melanomas, it was noted that there are many similarities in gene expression between DN and CN including those involved with mitosis, apoptosis, and transcriptional regulation.¹⁶ Nevertheless, DN demonstrate higher rates of Ki-67 positivity, a marker of proliferation, relative to CN. Levels of cyclin D1 and D3, which indicate cell division, are intermediate for DN between what is observed for CN and melanoma.^{17,18} Thus, DN may proliferate more actively than CN but not as significantly as melanoma.¹⁹ An autosomal dominant inheritance pattern for the nevus phenotype in melanoma-prone families has been postulated, with many of these families showing mutations at the CDKN2A locus.^{20,21}

Ultraviolet (UV) exposure has also been postulated to lead to the development of DN. However this is controversial, as some studies have failed to find a relationship between sun exposure and DN,²² while another study found that CAN density was greatest on skin that was intermittently exposed to sun—so-called *traumatizing exposure*—intense exposure that exceeds the natural resistance of the skin.²³ Finally, alterations in the host immune system may be related to the development of multiple DN (“eruptive DN”). This may occur in the context of immunosuppression for organ

transplants, chemotherapy, systemic immunosuppression from HIV, and certain hematologic malignancies.^{24–27}

Clinical features of CAN

The diagnosis of CAN is made clinically, and there are different sets of criteria to identify these nevi (see [Table 47-1](#)).^{28,29} In contrast to CN, CAN tend to be larger in diameter and may have some features of the ABCDs of melanoma (asymmetry, border irregularity, color variegation, enlarged diameter), which can make melanoma screening challenging in patients with numerous CAN. The criteria used by Tucker et al. are considered to be the most clinically relevant as they were used for one of the largest studies on melanoma risk and nevi. These consist of diameter ≥ 5 mm; presence of a macular component; and at least two of the following criteria: (1) variable pigmentation, (2) irregular and asymmetric outline, (3) indistinct borders.²⁸ The Dutch Working Group proposed an alternative set of criteria for CAN also shown in [Table 47-1](#).²⁹ Clinical examples of CAN are shown in [Figure 47-1](#).



Figure 47-1. Clinically atypical nevus.

Table 47-1. Clinical Criteria for Diagnosing Atypical Nevi

Tucker et al.²⁸	≥5 mm in size, having a flat component At least two of the following three: 1. Variable pigmentation 2. Irregular and asymmetric outline 3. Having indistinct borders
Dutch Working Group²⁹	1. ≥5 mm in diameter 2. Vague border 3. Asymmetric shape 4. Irregular pigmentation 5. Red hue

Histologic features of and pathologic reporting of DN

Histologically, DN have been described as having features distinct from CN. Clark et al.⁶ originally described DN as having both atypical cytology and architecture. These features included atypical melanocyte cytology, atypical melanocytic hyperplasia, papillary dermal fibroplasia, and a lymphocytic infiltrate. Other features of DN that have been described include elliptical nests with variability in shape and size which bridge adjacent rete ridges.³⁰ Epithelioid-cell hyperplasia is another growth pattern seen in DN, and is characterized by cells with large, rounded nuclei and abundant pale cytoplasm.³¹ Prominent vascularization in the papillary dermis can also be observed.³⁰ The World Health Organization has developed major and minor criteria for the histologic diagnosis, which was found to have an overall concordance of diagnosis for 141 specimens (including CN, DN, and melanoma) of 92% (see Table 47-2).³¹ Other groups such as University of Pennsylvania, the European Organization for Research and Treatment of Cancer, and Duke University (Table 47-3) have also reported guidelines for reporting and grading DN.^{32–34}

Table 47-2. Criteria for the Histologic Diagnosis of Dysplastic Melanocytic Nevi From the World Health Organization Melanoma Program³¹

Major Criteria	Minor Criteria
1. Basilar proliferation of atypical nevomelanocytes (extending at least three ridges or "pegs" beyond any dermal nevocellular component)	1. Presence of lamellar fibrosis or concentric eosinophilic fibrosis
2. Organization of this proliferation in a lentiginous- or epithelioid-cell pattern	2. Neovascularization
	3. Inflammatory response
	4. Fusion of rete ridges

Both major criteria and two minor criteria are required for diagnosis.

Table 47-3. Duke University Criteria for Grading of Dysplastic Nevi³⁴

Architectural disorder	1. Junctional component nested at both edges (0:Yes, 1:No) 2. Good overall symmetry (0:Yes, 1:No) 3. More than 5% nests cohesive (0:Yes, 1:No) 4. Suprabasal spread prominent or present at edge (0:No, 1:Yes) 5. More than 50% confluence of proliferation (0:No, 1:Yes) 6. Single-cell proliferation absent or focal (0:Yes 1:No) Score key: mild: 0–1; moderate: 2–3; severe: 4–6
Cytologic atypia	1. Nuclei round or oval and euchromatic (0:Yes, 1:No) 2. Nuclei larger than those of basal-layer keratinocytes (0:No, 1:Yes) 3. Nucleoli prominent (0:No, 1:Yes) 4. Cell diameter more than twice that of basal keratinocytes (0:No, 1:Yes) Score key: mild: 0–1; moderate: 2; severe: 3–4

Architectural disorder and cytologic atypia are scored separately by assigning a "0" or "1" for each criterion and summing.

Pathologic reporting of DN is variable across institutions and practices, with some pathologists grading them on a scale ranging from mild, moderate, to severe dysplasia, and others preferring to report lesions as having low- or high-grade dysplasia. Given that these distinctions between lower and higher

levels of dysplasia are based on degrees of histologic atypia interpreted by the dermatopathologist, it is important to note that variable interobserver concordance has been demonstrated, with the level of dermatopathologist experience potentially influencing the level of concordance.^{3,35} One study did show that with a rigid set scoring system in place, the discrepancies among study dermatopathologists remained largely within one grade of the mean (55% of cases) whereas only 3% of cases differed by two or more grades.³⁶ DN can be heterogeneous, meaning that atypical features may not be uniformly found across the lesion,³⁷ which can further nuance the grading of DN and lead to potential sampling error in partial incisional biopsies. The histologic features of a lesion have not been shown to correlate with the biologic behavior of the lesions.³⁸

CLINICAL SIGNIFICANCE OF CAN/DN AND RISK OF TRANSFORMATION TO MELANOMA

CAN/DN can have both sporadic and familial origins and are associated with an increased risk for melanoma. CAN/DN have been described in the context of familial atypical mole and melanoma syndrome (FAM-M), where patients have a family history of melanoma along with greater than 50 nevi, at least one with atypical histologic features. These individuals have a significantly increased risk of developing melanoma.³⁹ Nonfamilial CAN/DN as an isolated finding also confers an increased relative risk for developing melanoma of two- to eightfold.⁹ A case-control study showed that 15% of patients with melanoma were diagnosed with CAN/DN, compared to only 2% of controls.⁴⁰ Another case-control study found that the presence of CAN (defined by irregular pigmentation and/or irregular border with a diameter of at least 5 mm) was significantly associated with the risk of melanoma among English and Australian patients.⁴¹ Greater numbers of CAN appear to confer a greater risk for melanoma.²⁸ Moreover, a higher degree of atypia appears to correlate with an increased risk for melanoma: a history of mild, moderate, or severe atypia resulted in diagnosis of melanoma at a rate

of 5.7%, 8.1%, and 19.7%, respectively according to a study of 4,481 patients.⁴²

Although patients with CAN/DN are at increased risk for melanoma and need to be screened regularly, CAN are not obligate precursors to melanoma. CAN are not considered premalignant lesions or on a progression toward malignancy, unlike other models of dysplasia in cervical or colon cancer. Therefore, CAN can be clinically followed to assess stability, and biopsies may be reserved for changing lesions suspicious for melanoma, or those that may be bothersome or difficult to self-monitor. Melanomas can arise from both CN and CAN/DN. Although there have been computed estimates of transformation rates of nevi to melanoma,⁴¹ the true biologic transformation rate of a CAN/DN into melanoma is not known. Several studies have demonstrated a comparable risk of developing melanoma among both DN and CN, suggesting that DN may not have an increased risk for malignant transformation and therefore do not need to be managed more aggressively.^{43–46} Interestingly, in a study where histologically confirmed DN were transplanted into athymic mice, none were noted to transform into melanoma even following UV radiation.⁴⁷ Tucker et al. noted that among 844 individuals followed over a 25-year period, the majority of DN regressed or were stable.⁴⁸ Most melanomas develop de novo, with only 20% to 40% of melanomas arising from precursor nevi.^{49–51}

Clinical evaluation and management of patients with CAN/DN

Because of their increased risk for melanoma, patients with CAN/DN need to be screened for melanoma on a regular basis. Given that the clinical features of CAN may sometimes overlap with melanoma, and some patients may have numerous CAN, the clinical examination can be challenging. Various clinical clues have been identified to help detect lesions concerning for malignancy. These include the ABCDEs (asymmetry, borders, color, diameter, and evolution) and the “ugly duckling sign,” which uses the assumption that within an individual, most nevi tend to have similar phenotypic patterns, while a melanoma typically would stand apart in appearance.⁵² The overall

accuracy in clinically differentiating melanoma from CAN is estimated at 65% to 80%.^{53–55}

Dermoscopy (epiluminescence microscopy) may increase the accuracy of clinical melanoma diagnosis and is an important diagnostic tool when caring for patients with CAN/DN.^{56,57} Dermoscopy uses polarized light emitted from a handheld magnifying lens to visualize deeper pigmentation patterns as well as stromal and vascular structures within the skin. Studies have suggested that the use of dermoscopy increases melanoma diagnostic accuracy,⁵⁸ though training is necessary for this benefit.⁵⁹ There are six dermoscopic patterns into which the majority of DN can be classified: (1) reticular, (2) globular, (3) homogeneous, (4) reticular–globular, (5) reticular homogeneous, and (6) globular homogeneous.⁶⁰ Alternatively, DN can also be classified based on the pigment distribution with the following subtypes: uniform, multifocal hyper/hypopigmentation, and central or eccentric hyper/hypopigmentation. Various dermoscopy pattern analysis algorithms have been described to help distinguish melanoma from nevi.

Total body photography (TBP) is another tool to help in the management of CAN/DN patients by monitoring for changes in nevi over time compared to a baseline set of images. TBP is especially useful for those with large numbers of nevi or those with more complex nevus patterns with a variety of colors, shapes, and sizes. Used in many pigmented lesion specialty clinics across the country, TBP encompasses a series of photographs in standardized positions to optimize viewing of nevi and dermoscopy images of individual nevi, which are used by clinicians at follow-up visits for patients over time. Through total body baseline image comparison, new changes in pigmented lesions can more easily be detected. This method has been shown to allow clinicians to both accurately detect melanoma in the earliest stages, while decreasing unnecessary biopsies and patient anxiety.^{61–63} In one study published on TBP, biopsy rates of patients prior to care in a pigmented lesion clinic compared to rates after TBP in the clinic dropped significantly from 1.56 biopsies per year to less than 0.2 per year; a 3.8-fold reduction after TBP.⁶² Skin self-photography has also been described as a reasonable approach for monitoring when professional photography services are unavailable.⁶⁴

SURGICAL APPROACH

Deciding when and how to biopsy

The decision to biopsy a pigmented lesion is based on the degree of clinical suspicion for melanoma, with the goal of detecting melanoma at its earliest, most curable stage, while also avoiding unnecessary biopsies of banal, stable CN and CAN.² Other scenarios in which clinicians consider biopsies include nevi that are irritated, cosmetically concerning, or in areas difficult to self-monitor. It is important, in particular for patients with multiple CAN, to be educated that CAN are not obligate precursors to melanoma, and the vast majority remain stable over one's lifetime. Careful self-monitoring and clinical monitoring by a clinician for suspicious changes can be recommended and may prevent the morbidity, downtime, and anxiety produced with numerous biopsies and excisions. Prophylactic excision of all of a patient's nevi is both unnecessary and causes excessive morbidity to the patient. This strategy is also not effective at preventing melanoma, as melanomas may be more likely to arise de novo despite a patient having nevi.¹⁹

Prior to biopsy, the pigmented lesion should be examined to determine the best biopsy approach. Excisional biopsies are the preferred method for evaluating lesions that are suspicious for melanoma,² and the National Comprehensive Cancer Network (NCCN) and American Academy of Dermatology (AAD) guidelines recommend these biopsies be performed with a margin of 1 to 3 mm of normal skin beyond the area of clinical pigmentation.^{65,66} This can be accomplished with a shave/scoop, punch, or fusiform excisional biopsy depending on the size and location of the lesion (Table 47-4).

Table 47-4. Biopsy Techniques for Pigmented Lesions

	Technique	Benefits/Other Issues to Consider	Clinical Scenarios
Excisional biopsies	Shave/scoop excision	1. Complete assessment for accurate pathologic diagnosis assuming clinician did not transect peripheral or deep margins 2. Less invasive and fewer restrictions on patient activity given no need for sutures 3. Wound may take longer to heal by secondary intent	1. Lesions with higher suspicion for melanoma 2. Lesion in area of high tension or area difficult for primary closure (e.g., mid-back)
	Full-thickness (punch or fusiform excision)	1. Most complete control of peripheral and deep margins for accurate pathologic diagnosis. 2. Lower risk of clinical recurrence 3. Patient will have temporary restricted activity and sutures	1. Lesions with higher suspicion for melanoma 2. Primary closure is feasible
Partial incisional biopsies	Shave/scoop incisional biopsy	1. Fewer patient restrictions on patient activity given lack of sutures 2. Possibility of sampling error	1. Lesions with lower suspicion for melanoma; removal for irritation or cosmesis 2. Very large, suspicious macular lesion in which an excisional biopsy would be more complex
	Full-thickness (punch or elliptical) incisional biopsy	1. Patient may have temporary restricted activity and sutures 2. Can assess deeper components of lesion 3. Possibility of sampling error	1. Lesions with lower degree of suspicion for melanoma; removal for irritation or cosmesis 2. Very large, suspicious, papular or indurated lesion in which an excisional biopsy would be more complex

The benefit of an excisional biopsy is that it produces the most complete specimen for histologic examination. This increases the likelihood of a correct diagnosis for pigmented lesions, in which the histologic diagnosis hinges on viewing the complete architecture of a lesion as well as the range of cytologic atypia.² Although a clinician may choose between a shave/scoop versus a punch/fusiform excision, a recent study demonstrated that the degree of clinical suspicion impacted this choice, with the majority of surveyed clinicians choosing a full-thickness punch or fusiform techniques for a lesion with a high degree of suspicion for melanoma while shave technique was used more frequently for lesions with low degrees of suspicion.⁶⁷ Complete removal of a pigmented lesion also reduces the possibility of positive margins and recurrence. Recurrent nevi can appear clinically atypical and demonstrate histologic atypia that is nonmalignant (pseudomelanoma), histologically resembling superficial spreading melanoma resulting in a misdiagnosis.⁶⁸

There are certain clinical scenarios in which a partial incisional biopsy may be considered for pigmented lesions as well (Table 47-4). The AAD and NCCN guidelines support the use of partial incisional biopsy methods for certain anatomic areas (acral, cosmetically sensitive areas including the face), or for large lesions that would be difficult to fully excise.^{69,70} In these cases, the most clinically atypical appearing areas should be selected for biopsy.² However, in some instances incisional biopsies can fail to diagnose

a melanoma because sampling only part of a melanocytic lesion may not accurately reflect the biology of the entire lesion,⁷¹ and studies have revealed that clinical atypia may not necessarily correlate with histologic atypia.⁷² When partial incisional biopsy is used and obvious pigment remains, patients should be educated about monitoring for abnormal regrowth, and clinicians should continue to monitor the remaining pigmented lesion for the possibility of melanoma.

Punch biopsy/excision

Prior to performing a biopsy, the sites are typically cleaned with 70% isopropyl alcohol, anesthetized using lidocaine with epinephrine.⁷³ A punch biopsy relies on a metal cylinder with a sharp circular cutting edge to remove a full-thickness sample of skin, usually ranging in diameter from 2 to 8 mm. For pigmented lesions, the punch diameter should ideally extend at least 1 mm beyond the clinical pigment, with the goal of complete removal of the lesion. The clinician can score the skin around the pigmented lesion with light pressure to assess the correct-sized punch and map the best location for the punch to create clear clinical margins. The punch instrument is then rotated in a circular motion between the fingers until the instrument cuts through the dermis, meeting less resistance in the subcutaneous fat (Fig. 47-2), at which time forceps are used to elevate the section and cut it away from the subcutaneous tissue.⁷³

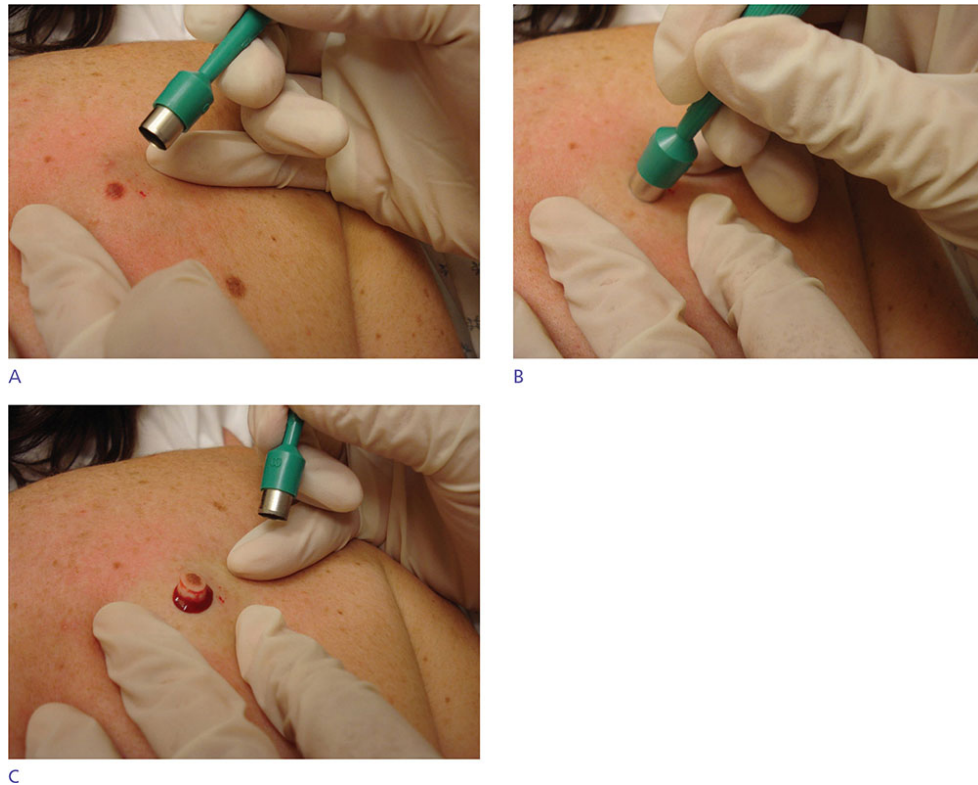


Figure 47-2. (A) Punch excisional biopsy technique (8-mm punch): Skin is held taut by hands and punch location is approximated to allow for margin of normal skin surrounding lesion. (B) Punch device is placed around lesion and rotated between fingers while applying pressure downward through the dermis until less resistance of the subcutaneous fat is felt. (C) The atypical pigmented lesion with surrounding 2 mm of normal skin is released by the punch technique, and the clinician cuts at the base of the tissue before placing sutures.

Hemostasis is achieved usually with one to three interrupted sutures; adhesive tape or a buried dermal suture can also be used for larger defects.⁷⁴ Nonabsorbable sutures are removed, in general, between 5 to 14 days postprocedure depending on anatomic site. Alternatively, if the punch is very small or the wound is very difficult to close primarily due to tension or other considerations, it may be appropriate to allow the wound to heal by secondary intention, in which case hemostasis can be achieved using gelfoam if desired. Electrocautery, aluminum chloride, or other hemostatic agents are less desirable because these methods may impact wound healing.⁷⁵ Punch biopsy sites that heal by secondary intention may be appropriate for younger patients who can easily care for their biopsy site, and may have outcomes comparable with 4-mm punch biopsies on the trunk or extremities that are closed with sutures. Older patients and those requiring larger punch biopsies

may not be good candidates for healing through secondary intention because the outcomes are suboptimal in terms of postoperative pain, healing time, and scar formation. Adhesives are insufficient for closing punch biopsies because they do not bear adequate tension.⁷⁶ An incisional punch biopsy by definition samples a portion of a larger lesion. For pigmented lesions, this may be considered in specific scenarios (Table 47-4). In general, although excisional biopsies are the preferred method of removal of lesions suspicious for melanoma, some pigmented lesions may be more difficult to remove in total due to size or sensitive anatomic area (such as on the face or feet), and clinicians may choose to sample a portion of these first. While not allowing a complete lateral architectural assessment of a lesion, the full depth of a lesion could be accurately assessed by punch biopsy, and therefore is desirable for palpable or indurated suspicious lesions.

Shave/saucerization biopsy and excision

Shave biopsies and excisions of pigmented lesions are rapid, commonly performed procedures that in certain clinical scenarios may result in comparable outcomes with punch biopsies or full-thickness skin excisions.^{77,78} In general, this procedure can be performed as a shave or saucerization using a sterile, flexible razor blade. Clinicians may choose to use either a 15-blade with a handle, a split sterile flexible razor blade, or a DermaBlade®. The skin is first anesthetized with an intradermal injection, which slightly elevates and tumescens the lesion and may make it easier to perform the biopsy. The nondominant hand is used to stabilize and hold the skin taut during the biopsy. Biopsies performed superficially may leave residual pigment either as a central dot or a peripheral rim.⁷⁸ This can be prevented by increasing the downward angle of the razor blade and lateral pressure. Another option for increasing the depth of the shave is to pinch the tissue beneath the nevus to create greater convexity of the area to be removed. Deeper shaves lead to more extensive wounds that may be associated with a depressed scar.⁷⁹ A 15-blade with handle may be used for saucerization of suspicious pigmented lesions in areas of higher tension such as the midback. In the saucerization technique, a 1- to 2-mm margin of normal skin around the lesion can be marked and scored by applying light pressure to the blade along the marking. This allows for control over the peripheral

margins of the biopsy. Light, continuous pressure is then applied tangentially through the dermis to the scored areas to release the skin specimen. The removed specimen is convex on its undersurface (Fig. 47-3).^{73,80}

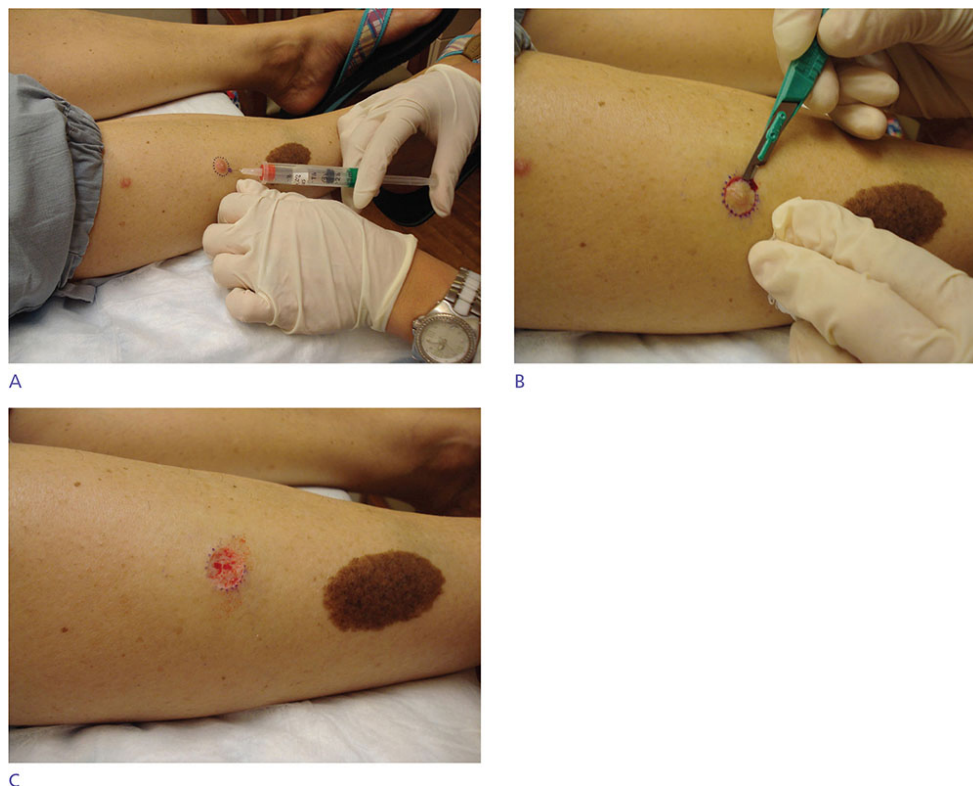


Figure 47-3. (A) Saucerization excisional biopsy technique: Lesion is marked with a surgical pen with 2- to 3-mm clinical margin of surrounding normal skin, cleaned, and anesthetized. (B) Marked lesion is scored around the margin, then blade is tangentially and continuously drawn through the dermis to scored areas. (C) Appearance of wound after removal of lesion.

Larger shave excisions and saucerizations may take longer to heal than incisions repaired with sutures, and patients should be educated to continue wound care until the skin is healed completely. Patients who heal with hypertrophic scars or keloids may prefer punch or elliptical excisions. However, most patients consider the scars following shave biopsy to be acceptable and preferable to other methods such as more invasive excisions into the deep dermis or superficial subcutaneous layer (Fig. 47-3).^{73,80} The shave biopsy technique has been associated with a higher risk of recurrence of pigmented lesions.⁸¹ In general, shave biopsies are more superficial than punch or elliptical excisions and are more likely to leave a positive deep margin, though clinician experience with the technique likely plays a role in

how accurately a pigmented lesion is removed, and many pigmented lesions are effectively biopsied in this manner.

Although excisional biopsies of suspicious pigmented lesions are favored, certain scenarios may cause a clinician to favor a shave incisional biopsy of a pigmented lesion. These scenarios include larger diameter lesions difficult to remove in total; lesions in certain anatomic areas (acral and face); and lesions removed that are of lower clinical suspicion, such as those removed for irritation or cosmesis ([Table 47-4](#)). Limitations, such as sampling error and inability to assess deeper tissue should be considered with shave incisional biopsies. As with any partial incisional biopsy, any clinical pigmented lesion remaining after the biopsy should be monitored for the possibility of melanoma.

Fusiform excision

The fusiform or elliptical excision is a versatile technique that is a cornerstone of dermatologic surgery and the definitive removal of atypical pigmented lesions. The excision should ideally encompass at least a 2-mm margin of normal skin around a pigmented lesion, and the fusiform design results in a defect three to four times longer than the width of the planned excision ([Fig. 47-4](#)).⁸² The incision extends to the subcutis and should preferably be oriented such that the scar lies parallel to relaxed skin tension lesions. After surgical planning and orientation are established, the skin is marked with a surgical marker, cleaned and prepped in a sterile fashion. Local anesthesia is administered. Once the incision lines are made to the subcutis, a uniform thickness of tissue is removed through the subcutaneous fat in the fusiform shape. After appropriate undermining and hemostasis are achieved, closure can be achieved by several methods with the goals to provide precise wound approximation, maximal wound eversion, and reduce tension on the wound.⁸³ A layered closure is generally performed. For a complete discussion of linear excision and repairs, see [Chapter 18](#).

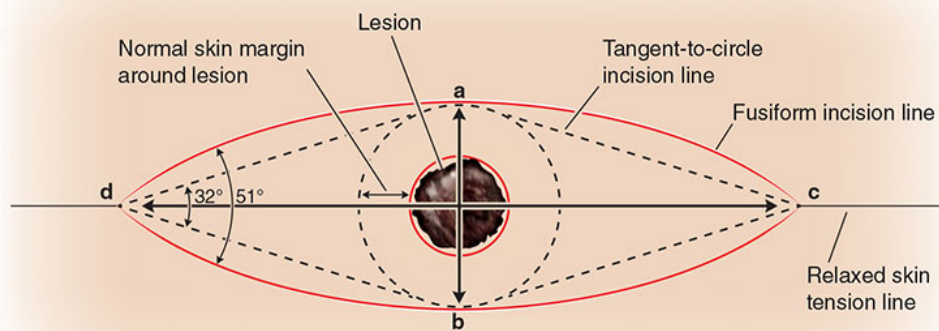


Figure 47-4. The fusiform excision.

Fusiform excisional biopsies with 2- to 3-mm clinical margins are an ideal way to achieve an excisional biopsy of suspicious pigmented lesions, as both peripheral and deep margins can be accurately controlled by the clinician. As the goal of the excisional biopsy being to remove the complete skin lesion for accurate diagnosis, margins beyond 2 to 3 mm are not necessarily needed at the time of initial removal. If the suspicious pigmented lesion is believed to represent melanoma, the possibility of a follow-up wide local excision with sentinel lymph node biopsy must be considered, and the clinician should be mindful of the orientation and size of the initial excision. This is important to allow for the greatest chance of closure of a second, wider excision and accurate sentinel lymph node mapping. Reexcisions of DN are also typically performed in a fusiform fashion to ensure complete removal of any residuum, with some clinicians favoring a 5-mm reexcision of severe DN via a fusiform excision.

Deciding when to reexcise DN

Despite the intent to perform an excisional biopsy of a pigmented lesion, histologically positive margins can be left behind. By definition, a histologically positive margin is expected in a partial incisional biopsy. The NIH consensus paper on DN from 1992 had no guidelines on reexcision of DN, and clinicians have had the challenge of determining when to recommend a reexcision after an initial biopsy of DN.⁹ The decision to

perform reexcisions for DN has been variable geographically as there is a paucity of data to help understand the actual risk of transformation of melanoma from DN. In 2002, a survey of members of the AAD revealed that 67% of respondents preferred to reexcise DN with a positive histologic margin.⁵⁶ However, several recent studies published have examined the role of observation for DN with positive histologic margins.⁸⁴ In addition, studies by Goodson et al. and Hocker et al. also observed a combined total of 184 DN with positive histologic margins, and no melanomas eventuated from the biopsy sites with greater than 2 years and an average of 17.4 years of follow-up, respectively.^{81,85} Two additional studies examined a total of 219 reexcisions of DN with positive histologic margins to assess for presence of melanoma in the reexcision specimen.^{86,87} While the study by Abello-Poblete found no melanomas within the reexcision of DN with positive histologic margins, the study by Reddy et al. found that 2 out of 127 reexcisions (1.6%) revealed melanoma in situ arising from initial lesions biopsied and diagnosed as moderately to severely DN, and the authors suggested reexcisions for higher-grade DN with positive histologic margins. More recently, a study of 498 patients with mild or moderate DN with positive margins at biopsy demonstrated a very low rate of conversion to melanoma, with 2% of observed DN demonstrating conversion to melanoma versus 0.06% or reexcised DN.⁸⁸ Though this difference was not statistically significant, the study may not have been powered to detect such a small effect size and therefore careful consideration of reexcision should continue.

Recent studies have shown that over time, more clinicians choose clinical observation for lower-grade DN with positive histologic margins. A 2009 survey of Chicago dermatologists revealed that while 79% of respondents observed mildly DN with positive margins, 81% reexcised moderately DN with positive margins, and 95% reexcised severely DN.¹⁹ In a 2014 survey of New England dermatologists on management of DN with positive margins and no clinical residual pigment, 95% of respondents observed mildly DN with positive histologic margins, while 39% observed moderately DN with positive margins, and 100% reexcised severely DN (see [Table 47-5](#)).⁸⁹ Most dermatologists agree that severe DN with a positive margin should be reexcised because of the possibility that these lesions may overlap histologically with early melanoma.^{56,89}

Table 47-5. Results From a 2014 Survey of New England Dermatologists' Management of Dysplastic Nevi With Positive Histologic Margins and No Clinical Residual Pigment⁸⁷

	Observe (%)	Reexcise (%)
Mild DN	95	5
Moderate DN	39	61
Moderate–severe DN	5	95
Severe DN	0	100

To highlight the clinical gap in recommendations for management of biopsied DN with positive margins, the Pigmented Lesion Subcommittee of the Melanoma Prevention Working Group published a consensus statement in 2015, and through the Delphi technique of consensus building, recommendations about management of DN with positive histologic margins were suggested by the authors.² Included in the recommendations was the consensus that DN with mild or moderate atypia and *clear* histologic margins do not need to be reexcised. Also, mildly DN with a positive histologic margin and no clinical residual pigmentation can be managed with observation. For moderately DN with positive histologic margins and no clinical residual pigmentation, the consensus statement recommended that clinical observation may be appropriate, though more data are needed. There was consensus that all severe DN with positive histologic margins should be reexcised to achieve a 2- to 5-mm clinically free margin.⁹⁰

OTHER CLINICAL RECOMMENDATIONS FOR PATIENTS WITH CAN/DN

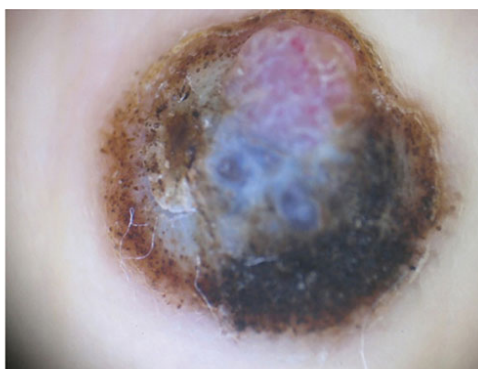
Patients with CAN/DN are at risk for melanoma and should be educated about the significance of their nevi as a risk marker—though not obligate precursor—for melanoma, reasons for biopsy, self-skin examinations, and sun protection. Monthly self-skin examinations can be recommended, and patients can be educated about concerning changes that should prompt clinical evaluation. The “ugly duckling” sign can be extremely helpful,

particularly for patients with numerous CAN. This helps patients streamline their examination and recognize usual patterns of their nevi, and to look for skin lesions that stand apart for any reason. Patients can be advised regarding wearing sun protective clothing, minimizing sun exposure, and applying sunscreen with SPF 30 or higher to exposed skin. In terms of other screening recommendations, a survey of dermatologists found that few clinicians advised patients to be examined by an ophthalmologist to check for ocular melanocytic neoplasms (2.9%), while 11.5% reported usually referring patients, and 45.5% stated they do so but infrequently.⁵⁶ Though many studies have identified a link between atypical mole syndrome and ocular malignant melanoma, a review article addressing this association also noted that there are several studies finding no such connection, so this relationship remains poorly defined.⁶⁷

Timing of follow-up visits can be individualized based on number of nevi, complexity of examination, degree of clinical and histologic atypia, and personal or family history of melanoma. In one study, for a patient with DN and no personal history or family history of melanoma, 58.8% of dermatologists recommended follow-up every 12 months, while 32.8% preferred every 6 months.⁵⁶ All prior biopsy sites should be monitored for change, and rebiopsied if changes are evident. Although recurrent pigmentation can occasionally be observed within a scar within the first several months after a biopsy, if new pigmentation extends beyond the scar or occurs after a longer delay post biopsy, this may be more concerning for melanoma, and the residual pigment should be rebiopsied (Figs. 47-5 to Fig. 47-7).⁹⁰



A



B

Figure 47-5. A 54-year-old female presented with an atypically pigmented plaque on her right lateral foot. She was not sure how long it had been present. An incisional shallow shave biopsy had been performed at an outside dermatology office, which revealed a severely atypical epidermal melanocytic proliferation. A narrow punch excisional biopsy was then performed of the remaining pigmented lesion, which revealed a 3.3-mm, Clark IV, nonulcerated invasive melanoma. The patient was referred to surgical oncology for a wide local excision and sentinel lymph node biopsy, which was positive. This case highlights a pitfall of the incisional shave biopsy, which can represent sampling error and not reveal the most atypical part of a pigmented lesion. When possible, an excisional biopsy is the preferred method of biopsy for a suspicious pigmented lesion on the skin. (A) Clinical photo of an atypically pigmented lesion on the lateral right foot, (B) close-up dermoscopy photo (10×).

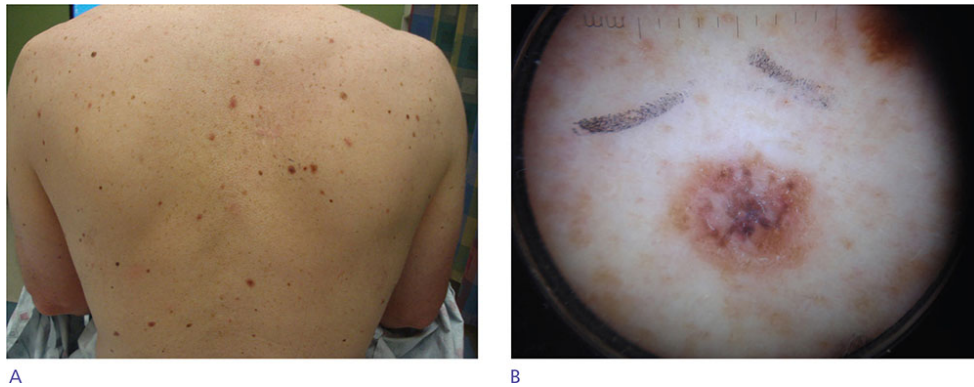


Figure 47-6. A 46-year-old male with >100 CAN returned for follow-up examination in the pigmented lesion clinic after missing several appointments. On examination, utilizing both total body digital mole mapping baseline comparison as well as dermoscopy, a lesion of concern was identified. This pigmented lesion appeared different from the patient's other patterns in coloration and in addition, it had a disorganized, asymmetric dermoscopy pattern with pigmented streaks and regression. An excisional biopsy was performed, which revealed a 0.56-mm, Clark level III, nonulcerated invasive melanoma. (A) Clinical photo of a patient with multiple clinically atypical nevi and (B) close-up dermoscopy photo of one lesion identified on examination with atypical pigmented streaks and regression (10×).

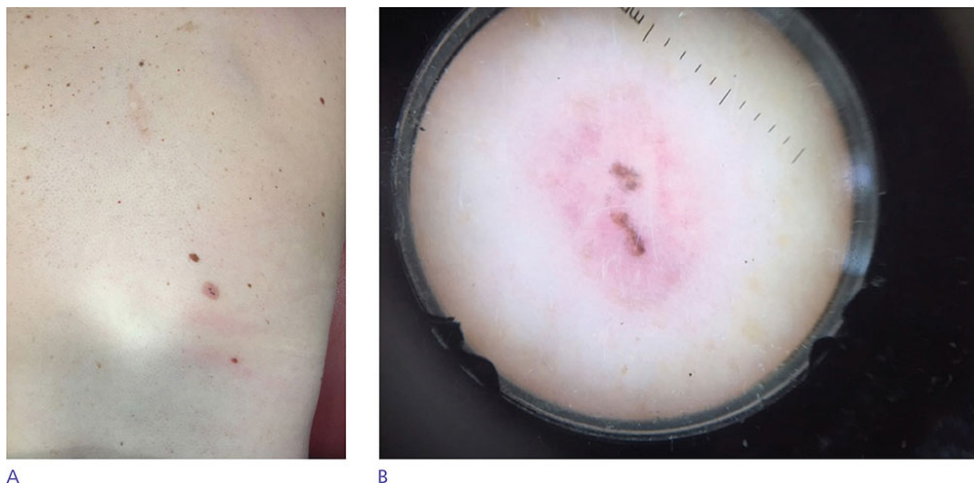


Figure 47-7. A patient who had a shave excision of DN on the right lower back revealing a mildly DN with positive histologic margins, returned for a follow-up visit several months later. Clinical examination revealed a small amount of pigmentation within the central scar. Given that the original biopsy revealed a mild level of dysplasia, the repigmentation occurred within the first several months of the procedure, and was contained within the scar, it was felt that the pigmentation represented a recurrent nevus, and has been clinically followed without further change. (A) Clinical photo of a patient with clinically atypical nevi after a shave excisional biopsy of a pigmented lesion on the back and (B) close-up dermoscopy photo of the scar (10×).

CONCLUSIONS

From a surgical perspective, most DN are easily treated with a linear excision. Biopsy should always be performed with the goal of obtaining a representative, and ideally entire, sample of the lesion. The phrase “excisional biopsy” includes a number of approaches including deep or scoop shave biopsy, saucerization, punch biopsy, and fusiform excision. Ultimately, any surgical intervention should be performed in the context of an overall management approach that is tailored to the individual patient.

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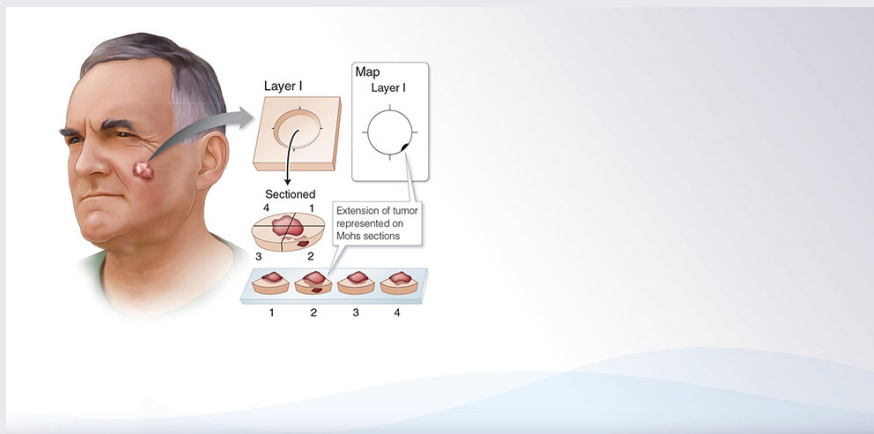
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CHAPTER 48 Nonmelanoma Skin Cancer

Alex M. Glazer

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Darrell S. Rigel



SUMMARY

- Nonmelanoma skin cancers are extraordinarily common, accounting for approximately 3 million new cases per year in the United States alone.
- Multiple treatment options are available, ranging from EDC to excision to Mohs surgery.

- Treatment decisions should be guided by both patient and tumor characteristics, and should always be individually tailored.

Beginner Tips



- Common treatment options for NMSC include EDC, excision, and Mohs micrographic surgery.
- The cost and ease of simple options such as EDC should always be weighed against both the increased healing time and decreased efficacy of these approaches when compared with excision or Mohs.

Expert Tips



- High-risk tumors may benefit from management in a multidisciplinary fashion.
- Adjuvant radiation therapy may be useful for select tumors at very high risk of recurrence.

Don't Forget!



- Select patients and tumors may benefit from primary medical management with topical or intralesional therapies.
- All surgical therapies entail risk, but this should be weighed against their effectiveness, rapid healing, and low recurrence rates.
- LN₂ treatment for NMSC is fundamentally different from AK treatment; intensity and depth of freeze must be significantly greater in order to lead to tumor destruction, and this will likely lead to significant surrounding tissue damage and hypopigmentation.

Pitfalls and Cautions



- Simple approaches such as cryotherapy and EDC should not be used on tumors at significant risk of recurrence.
- Appropriate tumor and patient selection for medical management or treatment with cryotherapy or EDC is critical; for example, some BCCs demonstrate both superficial and nodular growth patterns.

Patient Education Points



- Full informed consent includes a discussion of both the ease of a particular procedure and the length and complexity of the healing process.
- Remind patients that even with very low rates of recurrence or complications, those numbers are not zero. Patients may otherwise fail to appreciate that a 98% chance of tumor clearance without complications means that, for a surgeon who treats 100 patients per week, 2 patients weekly may have these undesirable outcomes.

Billing Pearls



- The AUC for MMS represent a guideline for patient and tumor selection, but individual LCDs also govern these decisions.
- Documentation is critical, and medical necessity is the ultimate arbiter of appropriateness.
- Some patients have poor (or no) prescription medication coverage; for them, medical management is generally not desirable.

CHAPTER 48 Nonmelanoma Skin Cancer

INTRODUCTION

Nonmelanoma skin cancer (NMSC) is the most common malignancy in the United States, with over 3 million cases annually.¹ NMSC is more common than all other malignancies combined, and its incidence continues to increase.² This burden has translated into a significant year-on-year increase in disease-related spending.³ As the incidence of NMSC continues to rise, there are significant public health, patient safety, and cost implications, making it imperative that clinicians be able to effectively treat NMSC.

MANAGEMENT OPTIONS

Basal cell carcinoma (BCC) and squamous cell carcinoma (SCC) are by far the two most commonly diagnosed NMSCs, with BCC outnumbering SCC. Additional forms of NMSC include Merkel cell carcinoma and dermatofibrosarcoma protuberans. Despite histologic differences, surgical treatment modalities for BCC and SCC are essentially the same. Other forms of NMSC are treated almost exclusively with excisional surgery or Mohs micrographic surgery (MMS).

Though NMSC is the most commonly diagnosed malignancy, these cancers account for less than 0.1% of all cancer deaths.⁴ Most cases of BCC and SCC have a relatively indolent course, and if detected early there are many treatment modalities available that readily achieve cure. Both surgical and nonsurgical options are available for the treatment of NMSC (Fig. 48-1).



Figure 48-1. Curettage of a nonmelanoma skin cancer.

In recent years, there have been significant advances in nonsurgical therapy for NMSC. Still, surgical treatment remains a well-tolerated and effective approach to clinical cure, and generally remains the standard of care. The most common surgical approaches to treatment of BCC and SCC include electrodesiccation and curettage (EDC), cryosurgery, excision, or MMS. Treatment choice depends on lesion location, patient's age, patient's health status, and risks for recurrence. Prior to deciding on a surgical treatment, a biopsy should be obtained in order to histologically examine the tissue to confirm the presence of malignancy. Sampling to the base of the lesion is helpful to guide treatment by stratifying the degree of risk associated with the biopsied lesion, though deep biopsy must be weighed against the risk of aesthetic and functional compromise. Once pathology is confirmed, the clinician must decide the best treatment modality based on both patient (age, site, immune status) and tumor (histologic subtype and degree of invasion) characteristics.

Surgery is the most commonly used treatment approach for NMSC. MMS has become the gold standard for treating NMSCs that are recurrent, complex, or on anatomic locations that benefit from tissue sparing. Other surgical and medical modalities are also effective for less complex lesions. A 27-year review of BCCs treated at NYU Skin and Cancer that compared

the efficacy of treatment with EDC, surgical treatment, and radiation therapy revealed that each of these methods have very high cure rates at 5 years.⁵ Regardless of what approach the clinician deems appropriate, the goal of therapy is to remove the tumor, achieve a high cure rate, preserve the maximal amount of normal surrounding tissue, and maintain an acceptable aesthetic and functional outcome.⁶

Electrodessication and curettage

EDC is one of the most commonly employed surgical techniques to destroy NMSC. This approach involves removal of diseased tissue with a curette followed by the application of a controlled electrical current to destroy the surrounding tissue. When considering EDC as a treatment modality for NMSC, it is important to assess the lesion depth, size, and location. Nodular and superficial BCC and SCC in situ without deep follicular involvement may be treated with EDC, though anatomic location and patient characteristics must be considered as well.

The clinician can distinguish between malignancy and normal dermis based on the degree of tissue friability noted during curettage, as most NMSCs are less cohesive and more friable than normal skin.⁷ Two techniques for curettage are frequently employed. First, the *pen technique* may be utilized, as the clinician holds the curette like a pencil in the dominant hand while stabilizing the lesion with the nondominant hand. Alternatively, the *potato peeler technique* is encouraged for larger tumors, and is accomplished by using the thumb to brace the tissue and create tension while the other four fingers are used to peel the lesion from the dermis.⁸ Whichever method is chosen, curettage is performed vigorously until pinpoint bleeding occurs and a firm, normal-appearing dermis is observed. There is a learning curve to distinguish the feel of NMSC versus normal tissue, though this is probably most reliable on the taut skin of the trunk and extremities and less reliable on the face.⁹

Following curettage, the lesion is treated with electrodessication, applying high-voltage electricity to the tissue to invoke superficial tissue destruction. Electrodessication of the wound is performed to thoroughly destroy any remaining viable tumor tissue at the base of the wound. The char effect of electrodessication may lead to higher cure rates; three cycles of

EDC has been proposed as the optimal treatment approach,¹⁰ though this has not been definitively demonstrated.¹¹ In general, a higher cure rate is achieved when an additional margin of healthy skin beyond the visually apparent lesion is treated,¹² though the exact margin has yet to be determined.¹³ The cosmetic result of EDC is site-dependent, with the best results being on the trunk and extremities (Fig. 48-2).



Figure 48-2. Electrodesiccation of a nonmelanoma skin cancer.

There is a large discrepancy in reported cure rates of NMSC treated with EDC. Several studies have assessed residual cancer following EDC and demonstrated residual malignancy in 8% to 12% of truncal lesions and 30% to 47% for facial lesions.^{9,14} Another study compared different treatment modalities by stratifying anatomic sites as low, moderate, and high risk for recurrence.^{5,15} Low recurrence risk locations included the neck, trunk, and extremities, with a 5-year recurrence of 8.6%. Moderate-risk locations included the scalp, forehead, and temples, and had a recurrence rate of 12.9% at 5 years. The nose, eyelids, chin, jaw, and ear were deemed high risk with a 17.5% risk of recurrence. In addition, this study noted that recurrence risk was correlated with the size of the lesion treated with EDC, with the highest cure rates seen with lesions less than 1 cm in diameter. Other

estimates show 5-year cure rates associated with EDC to be above 90%, and even higher when selecting low-risk lesions,^{11,16} though well-designed randomized controlled trials are lacking.

The use of biopsy to confirm NMSC depth and morphology may help optimize EDC usage. Deeply invasive SCC and micronodular or infiltrative (morpheaform) BCC are not amenable to EDC and should be treated with excision or MMS. In addition, recurrent NMSC at sites previously treated with EDC are best treated with MMS due to the presence of scar tissue and potential for skip areas and multifocal recurrence.¹⁷ Other relative contraindications to EDC include patients who readily form keloids. Moreover, patients with unshielded implanted electrical devices may benefit from electrocautery (thermal cautery) rather than electrodesiccation.

EDC cure rate is both lesion- and clinician-dependent, and it is therefore important to recognize the limitations of EDC so that clinicians provide and incorporate not only the least costly, but also the most curative method (Fig. 48-3).



Figure 48-3. Cryosurgery of a nonmelanoma skin cancer using the spray technique.

Cryosurgery

Cryosurgery is a minimally invasive ablative technique that uses a cryogen to destroy tissue by rapid freezing followed by a slow, prolonged thaw.

Cryosurgery is a simple, fast, and inexpensive approach to NMSC management, and is most appropriate for treating small discrete primary lesions such as superficial BCC and SCC in situ. Cryosurgery is particularly beneficial in patients with multiple NMSCs, as multiple lesions may be treated in a short period of time during a single office visit. This approach may be used safely in patients with complex medical conditions, though the ease of the procedure must be weighed against a possible extensive healing process. Moreover, cryosurgery does not provide any specimen for pathological examination. Treatment should include a 2- to 5-mm margin of normal appearing tissue to ensure adequate treatment.

The magnitude of destruction is a function of temperature, application pressure, and exposure time. Destruction of malignant cells requires temperatures between -40°C and -60°C . Liquid nitrogen (LN2) is the most commonly used cryogen in dermatologic surgery as its low temperature (-195.8°C) ensures the possibility of tissue destruction. The molecular basis for cryosurgery is multifactorial in nature (Table 48-1), involving direct cell injury during the initial freeze and mechanical destruction and crystallization of the cell wall leading to membrane instability and cell lysis.¹⁸ During the thaw portion of treatment, vascular injury occurs. Intense vasoconstriction during the freeze cycle changes vessel wall permeability, and when blood flow resumes during the thaw, compensatory hyperperfusion leads to free radical damage and membrane oxidation with ensuing ischemia.¹⁹ These mechanisms of injury lead to apoptosis even in regions where the temperature was not sufficiently low to lead to direct cell necrosis; in addition, an intense T-cell immunologic response occurs, further inhibiting tumor growth.^{20–22}

Table 48-1. Molecular Basis of Cryosurgery

	Mechanism	Time of Cycle
Direct injury	Ice crystal formation and cellular water movement	Freeze phase
Vascular injury	Circulatory collapse, free radical injury, membrane oxidation lead to ischemic necrosis	Thaw phase
Apoptosis	Programmed cell death in response to injury	2–8 hours post rewarming
Immunologic response	T-cell response	Late

The cryogen delivery unit must accurately and reproducibly achieve temperatures capable of eliciting cell death at the deep and lateral margins of the lesion. There are four central cryogen delivery techniques for cryosurgery to the skin:²³

- Open spray: LN2 is delivered through the open end of the cryogen delivery unit. Spray tips are available with different apertures to allow for treatment of different sized lesions. Larger nozzles freeze more quickly, leading to a greater but less precise area of destruction.
- Confined spray cones: This variant of the open spray technique uses a circumscribed cone on a plastic plate to concentrate the spray on a specific area. This also reduces inadvertent tissue destruction or splashing of LN2.
- Chamber or closed-cone: A metal cylinder with an open rubber-covered base is firmly applied to the target tissue to help achieve a deep freeze.
- Closed system or probe: Cryoprobes are metal devices used to make direct contact for cryosurgery. This allows for direct contact and delivery of LN2 through the probe. It is ideal for lesions in hard to reach areas with a flat surface.

Once the proper delivery device is chosen, the area is frozen by delivering LN2 to the affected area in a controlled manner. It is then allowed to thaw for 60 to 120 seconds to return to the original skin temperature. Since much of the vascular injury occurs during the reperfusion of the thaw cycle, it is imperative to allow complete thawing before repeating the freeze–thaw cycles. The optimal number of freeze–thaw cycles to adequately treat NMSC has not been determined. For very superficial NMSC, one cycle may be appropriate, though at least two cycles should be performed for thicker lesions. Studies suggest that the second freeze–thaw cycle increases the extent of original necrosis by 80%, significantly decreasing the risk of partial or inadequate treatment (Fig. 48-4).²⁴



Figure 48-4. Elliptical surgical excision of a nonmelanoma skin cancer.

Cryosurgery is typically reserved for BCC, well-differentiated SCC, and SCC in situ. Cure rates for cryosurgery at 5 years postprocedure have been reported as 93% and 96% for low-risk BCC and SCC, respectively, though like EDC it has not been rigorously studied in a randomized controlled trial setting.^{25–27} Its advantages include ease, speed, and low cost. Disadvantages are similar to EDC and include prolonged healing duration (which may last 4–6 weeks), pain and edema at the site, postoperative bullae formation, and associated hypopigmentation. Future use of optical coherence tomography and confocal microscopy^{28,29} may augment the reliability of cryosurgery, which may then be used as an adjuvant approach to minimize tumor recurrence.

Excision

Surgical excision is a mainstay of treatment for NMSC due to both the potential for rapid healing and the ability to examine tissue histologically to ensure complete tumor removal. Although EDC or cryosurgery may be appropriate for treatment of some NMSC, surgical excision has both a higher

cure rate and improved cosmesis over those options. Still, unlike MMS, where 100% of the margin is examined histologically, standard pathological review of a surgical excision specimen examines only a portion of the tumor margin. Tumors that are well defined are ideal for surgical excision, as the surgeon can assess clinical margins and confidently remove all of the tumor based on visual appearance alone.

Surgical technique for excision varies, though most lesions are excised with a fusiform ellipse with the long axis oriented along the relaxed skin tension lines. The length-to-width ratio of the ellipse should measure between 3:1 and 4:1 and the angles at the edges of the ellipse should be approximately 30 degrees to mitigate the risk of dog-ear formation. After the lesion is excised, the skin is undermined and a layered closure is performed. See [Chapter 18](#) for a detailed discussion of linear closure approaches.

The goal of surgical excision is to completely remove the tumor while minimizing the removal and destruction of normal skin. Typically, surgical excision of NMSC requires that a margin of healthy skin surrounding the tumor be removed due to the risk of subclinical tumor extension.³⁰ When performing surgical excision for NMSC, obtaining adequate surgical margins reduces the risk of positive histologic margins and the subsequent need for re-excision.³¹ In areas where there is limited excess skin and tissue preservation is vital, the limitations of excisional surgery must be recognized. In some circumstances, taking smaller surgical margins or referring for MMS may be more appropriate than simple surgical excision.

There are very few well-designed, qualitative, prospective studies examining appropriate surgical margins for NMSC. While some advocate a 4-mm margin,³² there is little evidence to support this, and individual practice varies.

BCC margins

Features of the BCC that must be considered before determining surgical margins are how well defined the tumor is, tumor diameter and histologic subtype, anatomic location, and any prior treatments the patient has undergone.³³ Ill-defined tumors may be poor excisional candidates because an accurate assessment of the clinical margin is often not possible. It may be difficult to determine the degree of subclinical spread for larger tumors, and such lesions may be more appropriately treated with MMS. Although 4-mm

margins are generally more than adequate for BCC, some circumstances require larger margins, and some tumors have very extensive subclinical spread.³² Larger and recurrent tumors may require a larger margin of up to 10 mm.³³ Very aggressive histologic subtypes of BCC (morpheaform and sclerosing) are not appropriate for surgical excision because of their tendency to demonstrate aggressive subclinical spread. Facial lesions and recurrent lesions anywhere on the body are generally considered high risk and thus may be more appropriate for MMS.

SCC margins

As with BCC, increased size, more invasive histological subtypes, and higher-risk anatomic locations are less conducive to surgical excision. One additional parameter that should be considered is vertical depth of invasion.³³ As SCC invades deeper within the tissue, the surgical margins needed to clear the tumor also increase. It is generally accepted that a 4-mm margin is adequate when excising a low-risk SCC, while a 6-mm margin is adequate for higher-risk SCC.³⁴ These numbers are based on a study that progressively excised 1-mm margins until cure was achieved, and found that 95% of low-risk SCC were cured at a 4-mm margin and 95% of high-risk SCC were cured at 6 mm.³⁵ Others have argued that these margins may not be appropriate, and have suggested margins anywhere between 2 and 15 mm.³³

In general, surgical excision has a very high cure rate for NMSC. Most tumors are adequately excised, but because there is no immediate histologic confirmation of negative margins, there is a risk for incomplete excision. One study showed that the cumulative 5-year recurrence risk with excision was 4.8% for BCC.³⁶ When stratified, the risk was lower on the trunk, neck, and extremities, and slightly higher for excisions taking place on the head, with recurrence rates being highest for larger (>10 mm) lesions on the head. Studies evaluating cure rate of surgical excision of SCC suggest recurrence rates of 8% and 23% for primary and recurrent SCC, respectively.³⁷ The clinician must decide whether wide local excision or MMS is most appropriate in the setting of tumor recurrence or incomplete excision, especially as data regarding BCC demonstrated that recurrent tumors treated with MMS have a 5.4% recurrence rate compared to a 17.4% recurrence rate when treated with re-excision.³⁷ Still, given their sometimes indolent nature and propensity to affect the elderly, it is important to consider either

approach, as well as watchful waiting, when deciding on management strategies for recurrent BCC in elderly patients. When considering recurrent SCC, MMS has similarly improved outcomes over standard re-excision.

Although guidelines for excision of NMSC have been set forth by the National Comprehensive Cancer Network, better-defined recommendations that take into account important tumor and patient characteristics need to be established. It is important to take into account the patient's history, tumor history and histology, anatomic location, and tumor size in order to achieve optimal outcomes for surgical excision of NMSC.

Mohs micrographic surgery

MMS involves tangential removal of tissue and immediate processing with frozen section histology in order to ensure that 100% of the tumor margin has been histologically examined and excised. It has the distinct advantage of ensuring almost complete histologic removal of the tumor in real time, and provides the least possible damage to adjacent normal tissues. Many studies have demonstrated both the safety and efficacy of MMS in the treatment of NMSC. The strength of the technique is that it has the lowest documented recurrence rate of any surgical treatment method and maximizes tissue sparing.^{37–39} For a full discussion of MMS, see [Chapter 29](#).

MMS is the treatment of choice for skin cancers on functionally or cosmetically sensitive areas, though it may be used anywhere the body. In general, MMS is indicated for NMSC in high-risk locations. It is also appropriate for larger tumors, incompletely excised tumors, tumors with aggressive histologic subtypes or indistinct clinical borders, and tumors in cosmetically or functionally sensitive areas.

The fresh frozen tissue technique⁴⁰ is performed by tangentially excising the tumor with a small amount of normal surrounding tissue. Orienting marks are made on the specimen and the corresponding site on the patient. The surgical specimen is then flattened in a manner that allows the three-dimensional margin to be cut in a two-dimensional plane and rapidly frozen. This allows the entire margin to be viewed in a microscopic section. The tissue is cut using a cryostat and the margin is mounted on one or more slides, then stained and examined by the Mohs surgeon. Typically, a hematoxylin and eosin (H&E) stain is used when examining NMSC, though other special

stains exist that are specific to different types of tumors. Positive margins are marked on an operative map, and additional tissue can then be removed to ensure the greatest possible tissue sparing. Processing of the tissue, histologic examination, and re-excision are repeated in stages until a negative margin is obtained.

Assuming that 100% of the epidermis and deep margin are visualized, once there are no positive margins, complete removal of the tumor has been achieved.⁴¹ The resulting defect from the excision can be repaired, allowed to heal by secondary intention, reconstructed, or referred to a colleague for reconstruction. Occasionally during the course of MMS, tumors will be encountered that are unresectable. This typically will not be apparent until many stages are performed or in cases of perineural invasion. When surgical margins cannot be obtained or complete resection cannot be achieved, it is helpful to map out the positive margins so that future surgery or radiotherapy can be targeted most accurately.

Indications for MMS have evolved as the technique has become more widely adopted and more actively sought out by patients. Appropriate use guidelines were developed by performing a thorough review of all available literature from 1940 to 2011 to help guide clinicians in determining when MMS is medically necessary.⁴² A rating system was developed to guide clinical decision making and ensure rational use of MMS depending on patient characteristics, type of NMSC, tumor characteristics, and clinical scenario.

MMS has been very well-studied for the treatment of NMSC, and has the highest cure rate of all treatment modalities for BCC and SCC. A review of the Australian Mohs database showed 5-year recurrence rates of primary BCC and SCC to be 1.4% and 2.6%, respectively.³⁸ In addition, it found the 5-year recurrence rates of recurrent BCC and SCC treated with MMS to be 4% and 5.9%, respectively.^{38,43} Other large retrospective studies have shown that MMS has lower recurrence rates than any other treatment modality in both SCC and BCC, likely because all of the tissue margins are examined.³⁷ Though MMS may be more costly than excision or EDC, several studies have highlighted its cost effectiveness, particularly because it can be performed in the office, the surgeon also acts as the pathologist, and it has an extremely high cure rate.⁴⁴

Operative considerations

All surgical approaches have risks including but not limited to bleeding, infection, risk of hypertrophic scar development, dyspigmentation, poor cosmetic outcome, and risk of incomplete treatment. These risks must be discussed with the NMSC patient in order to ensure that the patient as part of the informed consent process prior to deciding whether to undergo surgical management.

A detailed medical history should be obtained by the surgeon to ensure a thorough understanding of the patient's comorbidities and overall immune status.⁴⁵ In addition, the skin should be cleaned preoperatively in enlarging concentric circles beginning at the excision site and extending outward beyond the area covered by the sterile drape.⁴⁶ Bacteremia rates during cutaneous surgery have been documented ranging from 0.7% to 7%, which is similar to spontaneous bacteremia rates in healthy adults.^{47,48} The American Academy of Dermatology has recently reviewed and published a statement on the use of prophylactic antibiotics in dermatologic surgery, stating that it is unnecessary for cutaneous surgery unless mucosal skin is involved, the operative site is inflamed or infected, or the patient is high risk.⁴⁹ In these situations, a single dose of antibiotics should be administered 1 hour prior to surgery. Despite proper precautionary measures, wound infections will occur in approximately 2% of cases.⁵⁰ If this occurs, sutures should be removed and the patient should be started empirically on antibiotics such as a first-generation cephalosporin until culture and sensitivity results from the wound are obtained.⁴⁶

The risk of postoperative bleeding is generally low for dermatologic surgery. In order to minimize bleeding complications, all medications and supplements should be disclosed to the surgeon preoperatively.⁵¹ Patients taking aspirin are more susceptible to bleeding complications. There have been several published studies regarding the cessation of anticoagulants prior to dermatologic surgery, and in general the risk of postoperative bleeding after dermatologic surgery is much less than the risk of thromboembolic events. Therefore, medically necessary anticoagulants should not be routinely discontinued prior to surgery.⁵²

Medical therapy for NMSC

While EDC, excision, and MMS are the cornerstones of NMSC management, select, largely superficial, tumors may be managed noninvasively as well. Options include topical 5-fluorouracil and imiquimod for superficial BCC and SCC in situ, as well as photodynamic therapy. Topical 5-fluorouracil is typically applied twice daily for 6 weeks, with typical side effects including erythema, local irritation, and crusting. Imiquimod is typically applied daily five times weekly for 6 weeks, and has a similar side-effect profile to 5-fluorouracil.⁵³ Though these approaches may be useful in select tumors and patients, the inconvenience of multiple applications coupled with sometimes vigorous local tissue reaction and their modest complete clearance rate make these second line options for NMSC management.

Intralesional approaches represent another treatment modality for NMSC, though like medical therapies they have not been studied extensively. Intralesional 5-fluorouracil, methotrexate, and bleomycin have all been explored, and have demonstrated variable success in managing NMSC.⁵³

Advanced or unresectable BCC may also be treated using vismodegib, a novel hedgehog pathway inhibitor. Given the significant cost and, more importantly, side-effect profile associated with this treatment, it should be reserved for select cases that are not amenable to surgical management (Fig. 48-5).



Figure 48-5. Repair of an elliptical surgical excision.

Radiation therapy for NMSC

Radiation has been used for decades to treat NMSC, though generally its use has been limited by considerations of cost and convenience. Recently, superficial radiation therapy and electronic brachytherapy have again come into vogue, and their use by dermatologic surgeons in the United States has been increasing. Limitations of these approaches include a paucity of data regarding cure and recurrence rates as well as cost and availability. Radiation therapy may also be used as an adjuvant approach for select high-risk NMSC. For a complete discussion of these options for NMSC management, see [Chapter 37](#).

CONCLUSIONS

There are many surgical and nonsurgical techniques available to successfully treat NMSC. No multicenter studies are available to directly compare different surgical approaches for NMSC, though single-center studies

comparing the recurrence rates of EDC, cryosurgery, surgical excision, and MMS have generally shown that MMS has the lowest recurrence rate (Tables 48-2 and 48-3).^{37,54} In general, clinician comfort with each of these modalities as well as tumor size, clinical and histologic characteristics, patient age, anatomic location, and recurrence status will help to guide the clinician in choosing the most appropriate treatment.

Table 48-2. Estimated Cumulative Recurrence Rates for Primary BCC by Treatment Modality

Treatment	Cumulative 5-Year Recurrence Rate (%)
Cryosurgery	1.0–16.5
Curettage and electrodesiccation	2.0–26
Surgical excision	1.7–10.1
Mohs surgery	0.7–1.7

Data from Metterle L, Russell JS, Patel NS: An overview of the medical management of nonmelanoma skin cancer, *Curr Probl Cancer*. 2015 Jul-Aug;39(4):226–236.

Table 48-3. Estimated Cumulative Recurrence Rates for Primary SCC by Treatment Modality

Treatment	Cumulative 5-Year Recurrence Rate
Cryosurgery	Not available at 5 years, 3.2% in short term
Curettage and electrodesiccation	3.7%
Surgical excision	8.1%
Mohs surgery	3.1%

Data from Rowe DE, Carroll RJ, Day CL Jr. Prognostic factors for local recurrence, metastasis, and survival rates in squamous cell carcinoma of the skin, ear, and lip. Implications for treatment modality selection, *J Am Acad Dermatol*. 1992 Jun;26(6):976–990.

Though other options for NMSC management, such as medical therapies and radiation therapy, are becoming increasingly common, surgical treatments will likely continue to represent the primary approach to NMSC as they achieve high cure rates, have minimal side effects, reasonable cost, and acceptable cosmetic outcomes.

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CHAPTER 49 Keloids

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SUMMARY

- Keloids are a common problem, and occur disproportionately among patients with darker skin types.
- Dermatologic surgeons have several options available for keloid management, ranging from intralesional injections to excision and flap repair.
- Therapy must be tailored to the individual patient, as tolerance for invasive or costly therapies varies considerably.

Beginner Tips



- Intralesional steroid injections are the generally accepted first-line treatment for keloids.
- It is better to start with a lower volume and lower concentration (10 mg/cc) and move up if needed to minimize the risk of steroid-associated complications.

Expert Tips



- Laser and radiation approaches are generally best used as an adjuvant to excisional surgery.
- Combining meticulous surgical excision and another adjuvant therapy, such as radiation or intralesional injection, may yield the lowest recurrence rates.

Don't Forget!



- Cryotherapy may be associated with significant residual hypopigmentation.
- Bleomycin injections are often very painful, and local anesthesia is generally required prior to injection.

Pitfalls and Cautions



- Many of these treatments are not approved by the FDA for keloid treatment.
- Radiation in particular can be very costly, and patients should be aware of the potential costs and complications associated with the various approaches.

Patient Education Points



- Keloids are notoriously difficult to treat, and recurrence is possible even when combining multiple approaches and using meticulous technique.

- Overly aggressive steroid injections should be weighed against the potential for atrophy and telangiectasia development; patients should understand that these are common and expected side effects prior to initiating therapy.

Billing Pearls



- Excision and repair of keloids may be billed using standard excision (11400 series) and repair (12000 and 13000) series codes.
- If a flap is used, it should be coded independently without an excision code.
- Be sure to document the medical necessity for flap closure.
- Insurance companies are variably willing to cover the cost of radiation treatment of keloids; careful documentation of past treatments that have failed may help increase the likelihood that these approaches could be reimbursed.

CHAPTER 49 Keloids

INTRODUCTION

Keloids represent an aberrant response to wound healing, and are defined as thickened scars that spread beyond the boundaries of the original wound. Keloids may grow over time, and can be associated with symptoms such as pruritus, burning, and pain, and—particularly when located over joints—may lead to functional limitations. They may also lead to other physical limitations, such as dysuria or pain with ambulation when located in areas such as the genitals or feet, respectively. The greatest morbidity from keloids, however, is the psychological distress that stems from their sometimes cosmetically disfiguring appearance.

Several therapies have been developed to treat keloids, though no true cure exists, and no single treatment is consistently successful. Often, combinations of different therapies must be employed to achieve satisfactory outcomes. These include various topical and intralesional (IL) therapies, surgery, radiation therapy, and laser-based approaches. Moreover, strategies for the prevention of keloids should be discussed with all patients who have a history of keloid formation prior to undergoing invasive procedures, and possible steps to minimize their development or recurrence should be identified and implemented.

INTRALESIONAL APPROACHES

IL therapies are first-line treatments for keloids and hypertrophic scars.¹ IL therapies are able to effectively deliver active ingredients directly to the site of the keloid, minimizing systemic side effects. Various IL therapies have been evaluated for the treatment of keloids, including corticosteroids, 5-

fluorouracil (5-FU), verapamil, interferon (IFN), bleomycin, and botulinum toxin-A (BTX-A). The IL technique has also been used to deliver cryotherapy, and, more recently, for the insertion of a hydrogel scaffold to incision sites for prevention of keloid scars.

Corticosteroids

IL steroids are the mainstay of keloid management. Steroids function by several mechanisms, including inhibiting inflammatory cell migration and activation, reducing profibrotic mediators during wound healing, and by altering glycosaminoglycan synthesis.² They also reduce blood supply to the wound through vasoconstriction,³ and inhibit transcription of nitric oxide synthase leading to inhibition of collagen synthesis by fibroblasts.⁴ Triamcinolone acetonide (TAC) is the steroid most commonly employed, and is administered at a concentration ranging from 10 to 40 mg/mL, at intervals of 4 to 6 weeks. The medication is typically administered using a 30-gauge needle with goal of needle insertion within the papillary dermis.

As monotherapy for treatment of keloids, studies have reported efficacy rates ranging from 50% to 100%, though with recurrence rates of up to 50%. IL TAC has also been used extensively as adjuvant therapy post-excision. When combined with excision, recurrence rates are generally reported to be less than 50%.² The frequency and timing of adjuvant therapy injections have not been clearly defined, and a small study by Hayashi et al., suggested a new protocol for adjuvant therapy post-excision.⁵ The authors treated 21 keloids and 6 hypertrophic scars with IL TAC 10 mg/mL at suture removal, and then every 2 weeks, for a total of 5 treatments, in conjunction with topical steroids twice daily. They had a recurrence rate of only 14.3% for keloids and 16.7% for hypertrophic scars. Another study specifically evaluating IL TAC as adjuvant therapy after excision of earlobe keloids reported an efficacy of 87.6%, and a recurrence rate of 9.5% over a follow-up period of 29.9 months.⁶

Adverse reactions to IL steroids are generally mild. These may include pain or burning with injection, telangiectasia, atrophy, and pigmentary changes, which are cosmetically bothersome to patients and a limiting aspect of repeated therapy.⁷ Darougheh et al., reported atrophy and telangiectasias in 37% of patients treated with IL TAC.⁸ More rarely, necrosis and ulceration may occur.

5-Fluorouracil

5-FU is another effective treatment for keloids. 5-FU is a fluorinated pyrimidine that functions as an antimetabolite by inhibiting thymidylate synthase, thereby preventing ribonucleic acid (RNA) synthesis and function.⁸ 5-FU may also function by blocking collagen synthesis,⁹ and has been found to lead to decreased expression of TGF-beta in keloidal tissue.¹⁰ More commonly used as a chemotherapeutic agent, 5-FU has been studied extensively in the treatment of keloids, either as monotherapy, in conjunction with IL corticosteroids, or as adjuvant therapy.

As monotherapy, IL 5-FU is typically administered weekly at a concentration of 50 mg/mL, with generally no more than 2-mL injection performed at a visit.¹¹ In one study by Kontochristopoulos et al., 20 subjects with keloids were treated with weekly IL 5-FU 50 mg/mL, at an average volume of 0.2 to 0.4 mL/cm².¹⁰ Eighty-five percent of subjects had more than 50% improvement, with most improvement in small and previously untreated lesions, and recurrence was reported in 47%. The most frequent side effects were pain, hyperpigmentation, and sloughing; blood monitoring for changes in complete blood count, liver function tests, and renal function was performed, and did not reveal any alterations. Another study by Nanda and Reddy, found a similar response with greater than 50% improvement in most patients, and none of the 28 keloids treated recurred during a 24-week follow-up period.¹²

IL 5-FU is also an effective therapy in combination with IL steroids. A randomized-controlled trial of 150 subjects evaluated IL TAC alone or in combination with 5-FU.⁸ Subjects were randomized to one of two groups: group A, IL TAC 10 mg/mL, and group B, IL TAC 4 mg/mL with 5-FU 45 mg/mL. Both groups received weekly injections for a total of eight injections. Good to excellent results were reported in 84% of group B as compared to 68% of group A, and complications were reduced in group B (8%) as compared to group A (24%).⁸ In a systematic review comparing IL 5-FU to IL steroids, 5-FU was found to be effective as monotherapy, though only the combination of 5-FU with TAC was found to be superior to TAC alone.¹³

Finally, 5-FU can also be used as adjuvant therapy post-excision. In a study by Haurani et al., surgical excision was combined with monthly IL 5-FU 50 mg/mL, and resulted in a recurrence rate of 19% at 1-year follow-

up.¹⁴ In a meta-analysis including five publications, keloid recurrence was statistically lower in patients who received 5-FU postsurgical excision as compared to those who did not, while TAC was found to be ineffective at lowering keloid recurrence.¹⁵

Local reactions are common, including erythema, pain, burning, hyperpigmentation and ulceration, though these side effects may be ameliorated with the addition of TAC to 5-FU.¹⁶ Systemic side effects are generally not seen, and they have not been reported with use for this indication.

Verapamil

Verapamil is a calcium channel blocker that is used in the treatment of keloids. It has been shown to stimulate collagenase in keloidal tissue, resulting in reduced collagen and reduction of fibrous tissue formation.¹⁷ It is typically administered at a concentration of 2.5 mg/mL, though the interval of administration has not been well defined.

IL verapamil as monotherapy was found to have efficacy rates similar to IL TAC with fewer side effects, though the rate of achieving efficacy was slower in onset.¹⁷ Verapamil has also been studied as adjuvant therapy post-excision, though a recent randomized-controlled trial by Danielsen et al., found a significantly higher recurrence rate with IL verapamil as compared to IL TAC, resulting in early termination of the study.¹⁸

Interferon

IFNs are antifibrotic and antiproliferative cytokines that assist in the antitumoral and antiviral immune response.¹⁹ IFNs inhibit fibroblast proliferation and collagen synthesis, and increase expression of collagenase.²⁰

As monotherapy, IL IFN-alpha-2b was found to be ineffective in the treatment of 22 keloids in one study.²¹ Side effects were common, with seven patients withdrawing from the study because of severe local pain during injection. IL IFN may be more beneficial in combination with TAC. One study found a statistically significant decrease in size from baseline when IL IFN-alpha-2b was administered twice weekly in combination with TAC every 2 weeks, whereas TAC every 2 weeks alone did not produce a significant size decrease.²² IFN has also been studied as an adjuvant to

excision, where recurrence rates were lower (18.7%) than with TAC as adjuvant therapy (58.4%) and excision alone (51.1%).²³

Adverse reactions are common, and include generalized flu-like symptoms, pain on injection, local redness, and swelling.²⁰ Systemic symptoms may be improved by pretreatment with acetaminophen.

Bleomycin

Bleomycin is a cytotoxic antibiotic with antineoplastic, antibacterial, and antiviral properties. In dermatology, it is most commonly used for the treatment of recalcitrant warts, but has also been studied for the treatment of keloids.²⁴ In vitro, administration of bleomycin to fibroblasts has been shown to result in decreased collagen synthesis and increased apoptosis.²⁵

Bleomycin is administered at a dose of 1.5 U/mL through a multiple needle puncture approach after local anesthesia of the area is performed with IL lidocaine. In one study of 13 subjects receiving bleomycin 1.5 U/mL every 1 to 4 months, complete flattening was noted in 53.8% of subjects, and in the remaining subjects there was a greater than 75% resolution in scar thickness.²⁶ At 12 months, there was a 15.4% rate of recurrence. In another study by Saray and Gulec, bleomycin was injected into 15 keloids or hypertrophic scars that had been previously unresponsive to IL steroids through a jet injection technique.²⁵ After local anesthesia, multiple injections of bleomycin 1.5 U/mL were administered via a jet injector spaced 0.5 mm apart, with a maximum volume of 3.5 mL injected per session every 4 weeks until cosmetic improvement. Complete flattening is shown in 73.3% of lesions, and there were no recurrences during follow-up.²⁵

A common side effect of IL bleomycin therapy is pain, and therefore, local anesthesia is generally required prior to the procedure. Other potential side effects include ulceration, crusting, transient hyperpigmentation, and dermal atrophy.²⁴ No systemic toxicities have been reported with IL administration.²⁵

Botulinum Toxin-A

BTX-A is a neurotoxin that mediates its effects by preventing exocytosis of acetylcholine, thereby blocking neuromuscular transmission and resulting in muscle flaccidity.²⁷ Traditionally used for rejuvenation and facial rhytides, it has also been noticed clinically to improve appearance of scars.²⁸ The

mechanism of its effects in keloids may be related to reducing tensile forces across the wound, a factor known to be involved in keloid pathogenesis.²⁹ BTX-A has also been found in vitro to drive fibroblasts into the resting phase of the cell cycle.³⁰

BTX-A has been evaluated clinically for the treatment of keloids, though exact injection parameters have not been clearly defined. In one study by Zhibo and Miaobo, BTX-A was administered via 24-gauge needle to 12 patients with keloids; total dose ranged from 70 to 140 U per session.³¹ They reported excellent results in 25%, good results in 42%, and fair in 33%. Another study examined IL BTX-A injections in 19 patients at a concentration of 2.5 U/cm² monthly for 3 months; at 6 months, all patients had acceptable improvement and high satisfaction.²⁷ BTX-A may possibly represent a promising treatment for keloids when used in the appropriate setting, though further studies are needed and widespread use may be limited by its cost.

Intralesional Cryotherapy

Cryotherapy has long been used for the treatment of keloids. Cryotherapy freezes the keloidal tissue, leading to direct cellular injury with intracellular ice crystal formation, disrupting the intracellular organelles and plasma membrane.³² Traditionally, cryotherapy was administered as a spray, which has been reported to be beneficial,³³ though one common and cosmetically displeasing side effect resulting from this procedure is hypopigmentation, as melanocytes are more sensitive to cold destruction than fibroblasts.³²

IL cryotherapy was developed to prevent this side effect. It can be performed via several methods, including injection with a 20-gauge needle, multiple 18-gauge needle injections, or an IL cryoprobe. IL administration directly applies the cryogen to the core of the keloid, minimizing cellular damage to epidermal components, including melanocytes.³² van Leeuwen et al., treated 29 keloids with IL cryotherapy, and found an average volume decrease of 63% after 12 months, and a recurrence rate of 24%.³⁴

There is still a significant risk of hypopigmentation, particularly with darker skin types,³⁵ and a recent study evaluating temperature changes of the overlying epidermis using this technique found that the outer surface of the scar still reached temperatures below -20°C , colder than the freezing

temperature of melanocytes.³⁶ In one study, the hypopigmentation recovered in most keloids within 12 months.³⁴

Hydrogel Scaffold Device

A novel therapy for the prevention of keloid recurrence post-excision is the use of a hydrogel scaffold. This scaffold is composed of a porcine gelatin-dextran hydrogel scaffold injected into the wound immediately prior to skin closure.³⁷ It may function as a scaffold or lattice for fibroblasts, resulting in more appropriate migration and proliferation. This scaffold is currently approved in Europe for improvement of scarring. In one study of 26 ear keloids, the keloids were excised and then a maximum of 3 mL per 2.5 cm of the hydrogel scaffold was injected into the wound margin, followed by wound approximation and closure.³⁸ The recurrence rate was 19.2%, and patient scar satisfaction was very high. Further studies and US approval are needed before this approach could be widely adopted.

EXCISION

For keloids refractory to IL therapies, surgical excision is often the next step in management. Surgical excision is typically performed in conjunction with adjuvant therapy to minimize recurrence rates, as excision alone can result in recurrence rates of 50% to 80%.³⁹ Larger keloids and those present for shorter periods of time have a higher risk of recurrence.⁴⁰ Several options for adjuvant therapies can be considered, with IL steroids representing a common approach. After excision, the wound edges can be injected with steroids, though in such cases, suture removal is often delayed to reduce the risk of wound dehiscence.⁴¹

In general, similar principles that are important for wound healing are helpful for keloid surgery, including minimizing local trauma, minimizing tension across the wound, and appropriate wound margin approximation.

General Surgical Principles

Excision with primary closure is the main treatment modality performed for keloids that are amenable to this approach. This represents an appropriate option only if sufficient laxity of surrounding tissue is present so that the nascent wound is under minimal tension. If excessive tension is expected to

be present, either serial staged surgical excisions or other surgical approaches (discussed below) should be employed. Excision of the keloid should be performed just deep to the junction of the keloid and normal, unaffected skin.⁴² Trauma to the deeper portion of the unaffected dermis should be minimized to theoretically reduce the risk of keloid recurrence. Some surgeons advocate keeping the incision just within the keloid margins and leaving a small rim of keloid tissue, though this approach has not been studied extensively.⁴¹ When deciding on the appropriate excision margin, it may be helpful to note the vascularity of the tissue being incised, as keloidal tissue is less vascular than surrounding normal skin. Thus, once marginal bleeding occurs, the incision has entered into normal tissue. Additionally, a crunching sound is sometimes heard when incising the keloid proper, as the keloid is composed of fibrous tissue. The resolution of this sound signals suggests that unaffected skin has been entered.⁴³

After excision, the tissue edges should be handled as atraumatically as possible, and only the minimal amount of undermining necessary to relieve wound tension should be performed.⁴⁴ Potential sources of inflammation, such as trapped hair follicles, should be removed from the wound bed to minimize risk of recurrence.⁴¹

Suture Selection

Suture selection is important in minimizing risk of recurrence, and in general, monofilament, synthetic suture may be preferable to braided suture given its decreased tissue reactivity, which may minimize the risk of microabscess formation and inflammation, thereby decreasing the risk of recurrence.⁴¹ Durkaya et al., evaluated the role of sutures in a randomized-controlled trial of 60 patients with sternotomy scars where the wounds were closed via a subcuticular suture that was either braided polyglycolic acid or monofilament polypropylene suture.⁴⁵ Wounds closed with braided polyglycolic acid had significantly more hypertrophy than those closed with nonabsorbable monofilament polypropylene suture. Another study evaluated the risk of hypertrophic scar formation after breast reduction surgery, and found smaller and less reactive scars in patients whose wounds were closed with monofilament suture as compared to a braided suture.⁴⁶ These small studies suggest that monofilament suture should be considered when excising keloids, though further research in this area is needed.

Tension Minimization

Once suture material has been selected, the principle goal of suturing in prevention of keloid recurrence is minimization of tension. In addition to undermining and the selection of an appropriate closure technique for the given surgery, specific suturing techniques can be employed to minimize tension. Fascial plication sutures are sometimes employed to shift tension to the superficial and deep fascia, thereby reducing tension on the dermis and minimizing the need for dermal sutures.⁴⁷ Similarly, utilizing the set-back dermal suture technique, rather than standard buried sutures or buried vertical mattress sutures, may similarly help shift injury away from the wound edges; this approach coupled with postoperative electron-beam radiation resulted in a 2-year recurrence rate of only 2.2%.⁴⁸ A continuous intradermal suture has also been reported by placing nonabsorbable monofilament suture in both the deep dermis and superficial dermis,⁴⁹ which is then removed at the follow-up visit. Finally, a newer method for tension minimization after surgery is through use of a skin tension-offloading device. The Embrace Advanced Scar Therapy device was studied in a randomized-controlled split-scar trial of 65 adults status-post abdominoplasty, and found that mean visual analog scale score for embrace-treated scars was significantly improved compared with controls,⁵⁰ though further study is needed.

Additional Surgical Approaches

For keloids not amenable to primary closure, various surgical approaches have been developed. These include healing by secondary intention,⁵¹ healing with skin grafts,⁵² staged excisions, and surgical flaps.⁵³ Healing by secondary intention has the disadvantage of a prolonged healing time, scar contracture and recurrence, while grafts involve the risk of donor site morbidity and color mismatch.⁵³

The most important factor for a successful outcome after keloid surgery following an adjacent tissue transfer is to prevent flap necrosis by minimizing trauma to the flap and minimizing final wound tension.⁵⁴ Another important principle in achieving a successful result is the use of adjuvant therapy post-surgery to minimize recurrence.

Several flaps have been specifically described for the treatment of earlobe keloids, where primary closure may lead to earlobe distortion and

poor cosmesis. Adams and Gloster, reported use of a suprakeloidal flap for treatment of keloids.⁵⁵ A similar technique, the keloid fillet flap, has also been described (Fig. 49-1).⁵³ Another approach is through an X-shaped incision, which is marked on the surface of the keloid with the skin elevated from the surface of the keloid as four triangular flaps.⁵⁴ The keloid tissue is surgically dissected and excised, and the defect is closed. Finally, a subcutaneous V-Y (island pedicle) flap may be effective for keloids on the posterior aspect of the ear.⁵⁶



Figure 49-1. (A) Large keloid on the right earlobe. Previous treatment included intralesional steroids. The patient was treated with surgical excision using the keloid fillet flap, followed by adjuvant radiation. Postoperative visit showed slight dehiscence, which healed over the following weeks, and no recurrence was noted (B). Excision with adjuvant radiation is a good therapeutic technique when treating keloids located on the ears.

RADIATION THERAPY

Radiation therapy is becoming increasingly popular as adjuvant therapy post-excision in the management of keloids. Radiation therapy can be performed either as external radiation or brachytherapy. External radiation therapy may require a high dose of radiation,⁵⁷ while brachytherapy may lead to a more localized and targeted treatment. Brachytherapy can be further subdivided

into low-dose rate (LDR), where a low-dose radioactive source is used and withdrawn after 20 to 72 hours, and a high-dose rate (HDR), where a high-dose radioactive source is applied for only 5 to 10 minutes.⁵⁷ HDR may be associated with improved patient convenience.

The exact mechanism of how radiation therapy prevents scar recurrence is unknown; it is thought to function either by inhibiting fibroblast proliferation or by preventing the release of humoral or cellular factors that stimulate local fibroblasts to proliferate abnormally.^{57,58} Radiation therapy may also function by inhibiting angiogenesis, which is involved in keloid pathogenesis.⁵⁹

Radiation therapy has been studied extensively for the treatment of keloids. Shen et al., treated 834 keloids post-excision with electron-beam radiation therapy and found a relapse rate of 9.59%.⁶⁰ De Cicco et al., treated 70 patients status-post keloid excision with brachytherapy, either LDR or HDR, and they noted a recurrence of 30.4% in the LDR group and 38% in the HDR group.⁶¹ When all treatment modalities were compared in a systematic review including 33 studies, HDR brachytherapy showed the lowest recurrence rates (10.5%) compared with LDR (21.3%) and external-beam radiation (22.2%).⁵⁷ For external radiation, a shorter time interval (<7 hours) between excision and radiation treatment was associated with a lower recurrence rate (17%) as compared to a longer time interval (>24 hours), with a recurrence rate 21%, though the timing of therapy with HDR did not show this difference. While reports of adjuvant radiation after shave excision of keloids have been reported, 58 complete wound closure is generally recommended prior to radiation.

Dosing of radiation therapy varies in different protocols. Kim et al., performed a retrospective study of 39 lesions treated with keloidectomy followed by adjuvant radiation therapy.⁶² The lowest rate of recurrence was noted in patients who had undergone 1,500 cGy of radiation in three fractions. This protocol is often employed, and typically is begun on the day of surgical excision.

Adjuvant radiation therapy has some limitations. Relative contraindications for radiation therapy include pregnancy, age less than 12 years old, or presence of a keloid over radiosensitive locations (such as the thyroid gland).⁵⁷ Adverse events include skin erythema (early) and dyspigmentation (late).^{60,63} There is also a theoretical risk of malignancy, as

exposure to radiation is associated with radiation-induced cancers, though to date there have been no reports of radiation-induced malignancy when used for this indication, and the overall risk of cancer is felt to be very small.⁶⁴

LASER THERAPY

Laser therapy represents an additional therapeutic option for keloids. Various lasers, both nonablative and ablative, have been studied with variable success. Nonablative lasers include pulsed-dye laser (PDL) and neodymium:yttrium-aluminum garnet (Nd:YAG), and ablative lasers include carbon dioxide and erbium:yttrium-aluminum garnet (Er:YAG).

Pulsed-Dye Laser

PDL emits energy at wavelengths of 585- or 595-nm, targeting hemoglobin and oxyhemoglobin within red blood cells. This leads to selective photothermolysis of blood vessels, reducing vascularization of the keloid tissue and leading to tissue death and reduction in scar size.⁶⁵ PDL has been studied extensively for the treatment of keloids, but has had mixed results as monotherapy. In one study, 16 patients were treated with 585-nm flashlamp-pumped PDL and all patients demonstrated improvement in clinical appearance at 6 months.⁶⁶ Another study evaluated the longer wavelength 595-nm PDL, and found superior results for patients with darker skin types.⁶⁷ Other reports have shown minimal response or rapid recurrence following this treatment modality.⁶⁸ A systematic review including eight randomized-controlled trials found PDL to be superior to conventional modalities in improving overall scar appearance, though this difference was not present when individual scar parameters were evaluated separately.⁶⁹

The ideal fluence has not been defined, as no statistically significant difference was noted in one study between different fluences, and there was a trend toward better responses with lower fluences.⁶⁷ General recommendations are for the fluence to be in the range of 4.5 to 7.5 J/cm², depending on the spot size, with a higher fluence needed for smaller spot sizes.⁷⁰

PDL can also be performed in conjunction with other therapies. A single-blind, randomized-controlled trial of 69 patients treated with either weekly

IL TAC 10 mg/mL alone, weekly IL TAC with 5-FU (4 mg TAC with 45 mg 5-FU) or weekly IL TAC with 5-FU and 585-nm PDL for three sessions found the latter combination group to be most effective, with few side effects.⁷¹ PDL can also be used prior to IL injections as a means to facilitate injection by making the scar more edematous and more easily penetrable.⁷² Finally, PDL has also been used successfully post-shave excision in preventing recurrence.⁷³

Adverse events of PDL include atrophic scarring, pigmentary changes, dermatitis, and purpura.⁷⁴ Additionally, PDL has been reported to cause keloid formation when used for other indications.⁷⁵

Nd:YAG Laser

Nd:YAG laser emits light at a wavelength of 1064 nm, and therefore is able to penetrate deeper into the dermis. It is thought to suppress collagen synthesis by fibroblast inhibition.⁷⁶ Though less studied than PDL for keloids, in small case series, Nd:YAG has been shown to improve the cosmetic appearance of keloids, including pigmentation, vascularity, and thickness.^{77,78} Side effects were often mild, and most commonly included transient post-treatment erythema. When compared to 595-nm PDL in a randomized split-scar trial of 20 patients with hypertrophic scars and keloids, both treatments produced statistically significant improvement as compared to baseline, though there was no significant difference between groups.⁷⁹ More studies are needed to fully characterize the role of Nd:YAG in the treatment of keloids (Fig. 49-2).

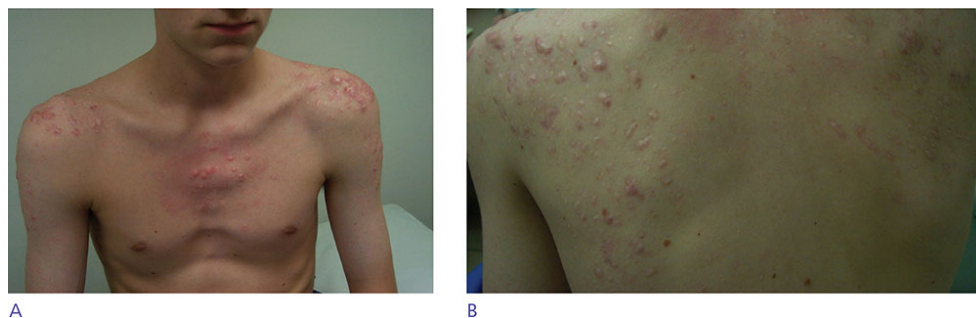


Figure 49-2. A young man with several keloidal papules on the chest, lateral arms, and upper back. The lesions are distributed in an acneiform distribution and were preceded by acne. In these cases, it is paramount to not only treat the bothersome keloidal lesions, but also treat the underlying acne, which is usually performed with more aggressive therapy if still active, in order to prevent new keloids.

Carbon Dioxide Laser

Carbon dioxide (CO₂) laser emits energy at a wavelength of 10,600 nm, which targets water within tissue, leading to vaporization and tissue destruction. Therefore, it functions as an ablative laser, and in treatment of keloids, causes necrosis of the keloidal tissue, remodeling of the scar, contraction, and ultimately, size reduction.⁸⁰

CO₂ laser has been used as monotherapy or in combination with IL steroids. As monotherapy, patients treated with CO₂ laser with a 2 mm spot size and W to achieve a power density of 500 W/cm² achieved successful results.⁸¹ When used in combination with IL steroids administered every 3 to 4 weeks, decreased recurrence rates were observed as compared to CO₂ laser alone.⁸² Common side effects of CO₂ laser include erythema and dyspigmentation.

Er:YAG Laser

Er:YAG laser emits a 2940-nm wavelength that also targets water, but as it has a shorter wavelength than CO₂ laser, does not penetrate as deep in the dermis, leading to reduced deep thermal damage.⁸³ It has not been as extensively studied for the treatment of keloids as other lasers, but in a randomized controlled trial, Er:YAG was effective in improving the clinical appearance of hypertrophic scars with less side effects as compared with CO₂ laser.⁸⁴

CONCLUSIONS

Keloids represent an abnormal response to wound healing, and their management can be challenging. Approaches include IL therapies, such as steroids, 5-FU, verapamil, IFN, and bleomycin; cryosurgery, including IL cryotherapy; surgical excision; adjuvant radiation therapy; and laser therapy. General surgical principles for tension reduction are of paramount importance in keloid surgery. Ideal management strategies vary based on lesion size and location, as well as patient preferences and motivation, and no one therapy is ideal in each situation. A recent treatment algorithm proposed beginning therapy with silicone gel or sheeting in combination with

IL steroids (alone or in combination with 5-FU), followed by laser therapy; if refractory, the keloid may be treated with excision followed by other adjuvant therapies, including radiation. Further research is needed to clearly define the ideal approach to keloid management.

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CHAPTER 50 Cysts

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SUMMARY

- Cysts are a frequent patient complaint, and removal may be motivated by tenderness, functional compromise, or aesthetic concern.
- Most cysts respond well to excisional approaches, ranging from small punch excisions to large elliptical approaches.

Beginner Tips



- Never attempt to excise an actively infected cyst; instead, consider I&D or a course of antibiotic therapy prior to attempting aggressive surgical intervention.
- Cysts that have been previously treated, infected, or manipulated will be more recalcitrant to treatment and may require sharp dissection or full excision.

Expert Tips



- With experience, cysts may be delicately dissected en bloc from a small incision site.
- Dead space minimization is vital for postoperative success, and may be accomplished via fascial plication sutures or percutaneous suture placement.

Don't Forget!



- Though minimal access incisions may be tempting, this must be weighed against the undesirable smell associated with cyst rupture which may be disturbing to the patient.
- Careful removal of all cyst contents and the entirety of the cyst wall will help mitigate the risk of recurrence or postoperative complications.

Pitfalls and Cautions



- Even expert diagnosticians may be fooled by cyst mimickers; therefore, all suspect cystic nodules should be removed, and every cyst should be sent for histopathology.
- Excising large cysts overlying nerve danger zones may entail a risk of permanent nerve damage; this should be explained to patients as part of the informed consent process.

Patient Education Points



- Patients should always be told that they are trading the cyst for a scar; if they are at all hesitant, defer the procedure.
- Even with complete excision, cysts may recur; patients should be warned that this is a possibility before starting surgery.

Billing Pearls



- Depending on clinical practice, most excised cysts are removed for symptomatic reasons, and are therefore billed with a benign series excision code (11400 series) coupled with a repair code (12000 and 13000 series).
- Be sure to document the rationale for the medical necessity of cyst excision if it is to be billed to insurance.
- Cysts removed purely for cosmetic reasons should not be billed to insurance.

CHAPTER 50 Cysts

INTRODUCTION

Cysts are frequently encountered in dermatologic surgery, and patients may present with a growing, irritated, or infected cystic nodule. While patients often present due to symptomatic concerns, they occasionally seek treatment for primarily aesthetic reasons. Most epidermal inclusion and pilar cysts can be identified clinically by their appearance and anatomic location, though excised cystic nodules should always be evaluated histopathologically, as other skin and soft-tissue tumors—everything from lipomas to Merkel cell carcinoma—can clinically mimic epidermal cysts.

EPIDEMIOLOGY

Many patients and nondermatologists refer to epidermal inclusion and pilar cysts colloquially as *sebaceous* cysts. This terminology should probably be avoided, as the only truly sebaceous cyst is a steatocystoma, which is encountered only infrequently, and is sometimes associated with pachyonychia congenita type 2 and steatocystoma multiplex.^{1,2} Epidermal cysts are synonymous with infundibular cysts or epidermal inclusion cysts, as they are all derived from the follicular infundibulum. These are sometimes divided into primary and secondary lesions, caused by follicular disruption or traumatic transformation, respectively.

Epidermal cysts are the most common type of cyst, and frequently occur on the face or upper trunk.³ When epidermal cysts occur on the scalp, they are sometimes clinically confused with pilar or trichilemmal cysts. Pilar (trichilemmal) cysts differ histologically from epidermal cysts, and occur almost exclusively on the scalp.³ Milia, smaller variants of epidermal cysts,

arise most frequently on the face in adults, though they may also be induced by secondary phenomena such as blistering, trauma, topical corticosteroid atrophy, laser resurfacing, and deep chemical peels.^{4,5}

Surgical excision is the mainstay of treatment for epidermal and pilar cysts, though other surgical modalities may be explored as well. When multiple cysts are present, underlying syndromes, such as basal cell nevus syndrome and Gardner syndrome,^{6,7} may be considered. Multiple milia can be found in the setting of oral–facial–digital syndrome, hereditary hypotrichosis, Rombo, and Bazex syndromes.⁵ Therefore, a complete history and physical examination are encouraged.

HISTOPATHOLOGY

Histologic evaluation of epidermal cysts reveals a stratified squamous epithelium with a granular layer surrounding central laminated keratin. Pilar cysts do not have a granular layer histologically, but do contain compact homogeneous eosinophilic keratin.⁸ Milia appear histologically similar to, but much smaller than, epidermal cysts.⁵

In contrast, steatocystomas, or true sebaceous cysts, histologically show a stratified squamous epithelium lined by an eosinophilic cuticle, commonly with sebaceous glands contained within the cyst wall.² Dermoid cysts are also composed of stratified squamous epithelium with a granular layer, but have additional associated dermal structures such as sebaceous glands, muscle, or hair surrounding the epithelial lining.

CLINICAL PRESENTATION

Epidermal inclusion cysts present as soft subcutaneous nodules, sometimes with a visible punctum (or puncta), and an associated yellow–white hue (Figs. 50-1 and 50-2). These contain macerated keratin, and cyst contents are most frequently white or yellow, though they can be brown or gray-colored as well. Cyst size and location are variable, but they are most frequently found on the face and trunk, and are typically a few centimeters in size, depending on location. Primary milia are usually 1- to 3-mm white papules, most commonly occurring around the eyelids and central face (Fig. 50-3).



Figure 50-1. Epidermal inclusion cysts present as soft subcutaneous nodules, sometimes with a visible punctum (or puncta), and an associated yellow–white hue.



Figure 50-2. Epidermal inclusion cysts may become fairly large, and are in variable proximity to the skin surface.



Figure 50-3. Primary milia are usually 1- to 3-mm white papules, most commonly occurring around the eyelids and central face.

Clinically, pilar cysts are indistinguishable from epidermal cysts, though they occur primarily on the scalp and may be more firm to palpation. This increased firmness corresponds to the thick wall of the pilar cyst, which also makes them more resistant to rupture. Unlike epidermal cysts, a punctum is usually not seen with trichilemmal cysts (Fig. 50-4).⁸



Figure 50-4. Unlike epidermal cysts, a punctum is usually not seen with trichilemmal cysts.

Compared to epidermal cysts, steatocystomas tend to be smaller, softer acneiform lesions (usually less than 1 cm) occurring on the chest and axillae (Fig. 50-5).² Dermoid cysts appear similar to epidermal cysts, but typically occur in infants and are located along embryonic fusion planes.^{3,9} Inflamed variants of each of these subtypes can occur, and will appear erythematous, warm, and tender due to the inflammatory reaction to the ruptured cyst wall and contents. Other common mimickers of epidermal cysts include lipomas, juvenile xanthogranulomas, and reactive lymph nodes.



Figure 50-5. Compared to epidermal cysts, steatocystomas tend to be smaller, softer acneiform lesions (usually less than 1 cm) occurring on the chest and axillae.

PATIENT EVALUATION AND SELECTION

Preoperative consultation is required to ensure adequate patient preparation and selection. This begins with a focused history, including prior excision, incision and drainage, or recurrent inflammation; this is helpful as there is increased risk of scar formation and recurrence as it may be more challenging to remove the cyst in its entirety.

Not all cysts are best served by immediate excision; inflamed cysts are better approached with intralesional corticosteroids or incision and drainage, as inflammation is an indication that the cyst wall has already ruptured. Inflammation causes local warmth, erythema, and pain from an acute foreign body reaction to the ruptured cyst contents. Occasionally, ruptured cysts become secondarily infected, requiring oral antibiotic therapy. In such cases, surgical excision should be delayed until frank infection has been cleared and the inflammation has markedly abated. A detailed conversation including the risks, benefits, and alternatives of surgery will not only permit the patient to better grasp the procedure, but may also help to

mitigate the risk of adverse outcomes by encouraging improved compliance with postoperative instructions. Patients should always be advised regarding the risks of cyst excision, including the potential for recurrence, infection, and scarring.

PREOPERATIVE CONSIDERATIONS

Motivation

Cysts are removed for both aesthetic and symptomatic reasons, though there may be significant overlap between these motivations. Enlarging cysts may become increasingly tender, and cysts overlying bony structures or pressure points are particularly prone to tenderness. Cysts that have been inflamed or infected may cause significant pain, distress, and scarring. Aesthetically, patients sometimes feel that the cyst is noticeable, and it may become a source of embarrassment. Most patients presenting for cyst removal overtly state that they would prefer a scar to the cyst.

Anatomic location

Location is an important consideration, particularly as cyst excision is often not truly medically required. Accordingly, the patient must be well informed and have reasonable expectations regarding the resulting scar. For example, if the patient has a cyst excised on the forehead or zygoma, they must understand that a scar will replace this cyst, and on these convex areas, a scar may be particularly evident. Cysts removed from thicker-skinned areas (such as the back and flank), as well as the extremities, may require longer and larger excisions, as thinner-skinned areas are more flexible and malleable, allowing much of the cyst and contents to be squeezed out successfully from a smaller incision. Finally, cysts overlying anatomic danger zones should always be approached with caution, especially as they may extend deeper than anticipated; thus cysts on the preauricular area or over Erb's point should be dissected carefully, and patients should be warned preoperatively regarding the risk of permanent nerve damage.

Lesion history and current state

Important considerations include the length of time that the cyst has been present, whether it has ever been irritated or inflamed, whether it has been otherwise traumatized or partially removed, and whether excision has been previously attempted.

General preoperative considerations

In addition to a problem-focused physical examination and explanation of any proposed procedure, general history should include medical, surgical, and social history and a review of current medications and allergies. Medical conditions may impact outcomes in dermatologic surgery, and these should be reviewed carefully, particularly if the patient has a history of hypertension, diabetes, smoking, alcohol use, or other cardiovascular disease.

SURGICAL APPROACHES

Instruments

A standard dermatologic surgery instrument tray (see [Chapter 5](#)) may be used ([Fig. 50-6](#)). Some surgeons favor a serrated jaw forceps with no teeth for grasping the delicate cyst wall, as teeth may increase the risk of cyst wall puncture. Alternatively, hemostats may be used as well. A curette is sometimes useful when the cyst wall is adherent to surrounding tissue, and when en bloc resection is not planned, as it permits the surgeon to scrape the cyst contents from adjacent tissue with minimal damage to normal tissue.



Figure 50-6. Surgical tray for cyst excision. From left to right: skin hook, surgical blade handle, curette, tissue forceps with serrated jaws, tissue scissors, hemostat, suture scissors, and needle holder.

Preoperative preparation and anesthesia

A surgical marking pen is used to mark the punctum and the palpable margins of the cyst prior to local anesthetic infiltration, as local anesthesia may distort the cyst boundaries (Figs. 50-7 and 50-8).



Figure 50-7. A moderately-sized cyst is seen on the right cheek.



Figure 50-8. A surgical marking pen is used to mark the punctum and the palpable margins of the cyst prior to local anesthetic infiltration, as local anesthesia may distort the cyst boundaries.

Tegaderm, a transparent film dressing, may be applied overlying the cyst immediately after marking and prior to local anesthetic infiltration. This may serve to mitigate the risk of cyst contents or local anesthetic agent backsplash contaminating the injector. The film is removed after local anesthesia infiltration, and the area is cleaned and sterilized per standard protocol (Fig. 50-9).¹⁰



Figure 50-9. Tegaderm, a transparent film dressing, may be applied overlying the cyst immediately after marking and prior to local anesthetic infiltration. This may serve to mitigate the risk of cyst contents or local anesthetic agent backsplash contaminating the injector. The film is removed after local anesthesia infiltration, and the area is cleaned and sterilized per standard protocol.

Injection of a local anesthetic agent may help to dissect the cyst from the surrounding tissue. If considerable fibrosis or scar tissue exists, little separation of the cyst from the surrounding tissue will occur. Care should always be taken not to inject directly into the cyst cavity, which may lead to cyst distention and possible rupture. Additional anesthetic can be infiltrated more deeply beneath the cyst as dissection and removal progresses, if necessary. Warning patient preoperatively that local anesthetic infiltration deep to the cyst may be incomplete may be worthwhile. Additionally, local anesthetic effect may be impeded in the acidic context of an infected cyst,

though such cysts should generally not be approached surgically until the bulk of infection has been cleared through either incision and drainage or systemic antibiotic therapy.

Surgical technique for epidermal cysts

There are many surgical approaches to epidermal cyst removal. Whichever approach is utilized in removal, extraction of all components is important, as residual cyst wall and cyst contents will increase the chances of recurrence and infections. The punctum or dilated pore in the skin overlying the lesion should be identified whenever possible, as the cyst adheres to skin at the site of the pore. In complete surgical excisions, the planned incision lines, oriented along relaxed skin tension lines, should include the epidermal pore if possible, and the goal is to create as small and/or imperceptible a scar as possible.

Slit incision with dissection

After a single incision line is marked over the cyst, including the punctum centrally, a shallow incision is made along the marked line. As with traditional elliptical excision, care must be taken not to incise too deeply and inadvertently incise into the cyst. Beveling the scalpel blade outward (a reverse bevel) may decrease the chance of cyst wall rupture. If the punctum is large it may be removed. Once the cyst wall has been identified, grasp the epidermal edge with a skin hook and dissect the cyst wall free from the surrounding skin and subcutaneous tissue with iris or small gradle scissors. Firmly grasp the cyst with tissue forceps or hemostat and deliver it through the incision if possible. If the cyst is too large for the incision size, it may be decompressed by making a small incision in the wall and with gentle lateral pressure expressing some of the keratinous contents through the incision. The partially collapsed cyst sac may then be delivered more easily through the incision. Be careful to ensure complete removal of cyst wall and the cyst contents to prevent recurrence. Lengthening the incision may be necessary. Though partially expressing the cyst contents is possible, en bloc cyst removal after dissection obviates patient concerns regarding the malodorous cyst contents and mitigates the risk of leaving residual keratinous debris in the excision site postoperatively. Layered wound closure should be

completed as for traditional elliptical excision, taking care to reduce dead space.

Minimal or punch incision with expression

Squeezing the capsule and contents through a minimal incision is another option for cyst removal.¹¹ Under local anesthesia, a stab incision is made in the center of the cyst using a no. 11 blade or trephine. When a punctum is visible, it should be included in the incision. Gentle lateral pressure is applied, expressing some of the cyst contents through the incision. The opening is extended using a hemostat, and the contents are gently expressed. A small curette may then be used to remove the remaining keratinous debris and to free the cyst wall from the surrounding tissue. Once visualized, the cyst wall is then grasped with the hemostat and removed. The cyst wall should be entirely removed, leaving no residue. Cyst contents may contaminate the wound during this procedure, and gentle irrigation should therefore be performed along with probing the wound with a curette to remove any residual keratinous fragments prior to closure.¹² Skin hooks work well to retract the wound edges and thoroughly inspect the margins of the wound for any residual cyst wall.

Alternatively, substituting a biopsy punch for a scalpel has been described as another minimally invasive method for cyst removal.^{13–15} The punch hole may allow for better visualization and easier removal of the cyst wall as compared to a small linear incision, which often needs to be extended in order to remove the cyst completely, resulting in a longer scar. The biopsy punch is inserted perpendicular to the surface of the skin, preferably over a visibly enlarged punctum, until it penetrates the wall of the cyst. The overlying skin is then removed with iris or gradle scissors and the contents of the cyst are squeezed through the hole until no further material can be extruded. At this point the remaining cyst wall should be removed as described above. Usually, with appropriately chosen cysts, simple pressure is enough to dislodge the wall from the surrounding stroma, though it is sometimes necessary to dissect the wall away from the adjacent connective tissue with surgical scissors.

The resulting defect from incision or punch can be either sutured closed or allowed to heal by secondary intention. Warm compresses may be used for several days following surgery if the latter method is chosen. Healing by secondary intention is an acceptable option if the defect is very small (2 to 3

mm), if it is in a cosmetically unimportant area, or if there is any doubt that the entire cyst wall and its contents have been removed. The benefits of secondary intention healing should be weighed against the risk of the wound healing as a dilated pore or depressed scar.

Wide excision with layered closure

This is a reliable technique to prevent recurrence,¹⁶ saving the patient further procedures, time, and expense. It is often indicated for larger cysts or those with previous inflammation, infection, or drainage suspected of having considerable surrounding fibrosis and scarring. The central disadvantage of this method is a longer scar and increased wound tension due to the removal of a fusiform ellipse of tissue.

After an ellipse is marked over the cyst, including the punctum centrally, and injection of local anesthetic around the cyst is complete, a shallow incision is made along the marked lines. As some cysts are quite superficial, care must be taken not to incise too deeply initially and inadvertently incise into the cyst. If the cyst has not previously been treated, the cyst wall may be visualized. Once the skin incision is made to the level of the cyst wall, the skin away from the ellipse can be carefully undermined to separate it from the cyst wall. A skin hook and iris or small gradle scissors work well for this approach. This process may be assisted by traction on the ellipse and underlying cyst using a hemostat, finely serrated tissue forceps, or stay sutures. The angles of the ellipse should be released to complete full cyst dissection. Often the cyst can be removed in its entirety without rupture. En bloc surgical excision may also remove considerable fibrosis or scar if present. This method also provides a large and well-oriented specimen for pathologic evaluation, useful when malignancy is suspected.^{11,16}

Dead space closure is used to mitigate the risk of hematoma or seroma formation, as well as the risk of a dimpled or depressed scar. Layered closure with fascial plication sutures may be particularly helpful in this regard, and a layered closure is very helpful.

Previously manipulated (excised, incised and drained, or infected) cysts may be multiloculated, with significant surrounding scar tissue and adhesions. Such cysts are challenging to remove through a small incision, and have an increased chance of recurrence. Therefore, wide en bloc excision is preferred in these cases to ensure complete removal.

Incision/extraction of milia

Milia can usually be removed easily by nicking the overlying skin with a no. 11 blade or lancet and removing the lesion with gentle lateral pressure using a comedone extractor. Alternatively, these lesions can also be removed by making a small incision using the tip of a sterile disposable needle and using the needle to enucleate the cyst. Larger lesions, particularly those around the eyes, may require a slightly longer incision with removal of the sac using fine forceps. They usually heal well by second intention, or the placement of a few superficial sutures for larger lesions. New lesions are likely to occur, though treated lesions usually do not recur.

Surgical technique for pilar cysts (scalp)

Slit excision is a technique commonly used to remove these types of cysts on the scalp. Many patients avoid removing these because they fear that the surrounding area will be shaved. In general, shaving or clipping the hair is unnecessary beyond the small area overlying the portion of the scalp that may be excised completely. This is enormously appreciated by patients, and serves to make removal a very quick procedure that is gratifying for both the patient and surgeon.

The area is first cleaned with chlorhexidine, pushing the hair in all directions away from the cyst. When dried, this assists in keeping the hair back away from the site of cyst removal. Additionally, ointment can be applied to the surrounding area, further helping to keep back the hair. Sterile hair clips and/or cloth tape may also be used in preventing hair from interfering with the procedure. Keeping hair from interfering with the procedure will not only make it easier, but hair that is drawn into the wound at the time of closure can become a nidus for infection or later cyst formation, and should be avoided. The surgical incision is started superficially, with the goal of visualizing the cyst without puncturing the wall. Once the wall is visualized, and after careful undermining laterally, gently applied lateral pressure alone often permits the cyst to easily emerge fully intact. This is the ideal scenario, as it ensures that the entire cyst has been removed and there will be little chance of recurrence. This approach results in no tension on the wound edges, though buried sutures may be helpful for dead space minimization.

Pilar cysts enlarge over time, leading to redundant skin development, particularly overlying larger cysts. This redundant tissue will often need to be removed at the time of closure. Large pilar cysts may include distorted hair shafts, decreased hair growth, or even complete alopecia over the central portion of the cyst, and this alopecic skin may be trimmed and removed at the time of closure. Percutaneous suturing approaches (see [Chapter 13](#)) may be helpful to reduce dead space when working in narrow scalp wounds.

Due to the vascularity of the scalp, postoperative bleeding is a risk, and careful intraoperative hemostasis coupled with dead space minimization and a pressure dressing application are helpful. Pressure dressings should ideally remain in place for 24 hours, and can be secured with a tie-over pony-tail utilizing the patient's own surrounding hair ([Fig. 50-10](#)).



Figure 50-10. Pressure dressings should ideally remain in place for 24 hours, and can be secured with a tie-over pony-tail utilizing the patient's own surrounding hair.

NONSURGICAL MANAGEMENT

Occasionally, patients present with the goal of decreasing cyst inflammation but prefer to avoid surgical management. In such cases, intralesional and perilesional corticosteroid injection may be helpful, though patients should be warned that this addresses only the underlying inflammation, and that the cyst proper is unlikely to resolve. Similarly, incision and drainage may be used for inflamed epidermal cysts when excision would not otherwise be recommended (see [Chapter 17](#)). These approaches may be combined with the anti-inflammatory effects of NSAIDs and periodic application of warm compresses to encourage drainage and decrease pain. If infection is also suspected, prescribing an oral antibiotic to rapidly reduce the associated erythema and pain should be considered.

COMPLICATIONS

Rupture and liquefaction

Epidermal cysts typically have a thin wall that can tear easily during removal and rupture the cyst, and larger cysts often have thinner walls. If a cyst has previously been inflamed, the contents may be liquefied due to previous inflammation. Pilar cysts have a thicker cyst wall, making them more resistant to rupture, and they more commonly extrude easily with gentle pressure.

Secondary infection

Cysts are frequently mislabeled as infected rather than simply inflamed and irritated, especially as inflammation creates a vigorous foreign body inflammatory response leading to erythema, edema, and tenderness, simulating an abscess. Incision and drainage will often relieve the pressure and pain immediately; cultures are usually negative, and antibiotics are infrequently needed. For patients that are reluctant to undergo an intermediate procedure, antibiotic therapy may lead to significant reduction in erythema and edema, and the patient may then return in 2 weeks for a standard excision of the cyst.

Recurrence

If an epidermal cyst is not removed in its entirety, there is a chance of recurrence; this is possible even when the cyst wall is removed in its entirety, as tiny daughter cysts may exist adjacent to a larger cyst. Previously removed or manipulated cysts are at increased risk of recurrence. Patients should be informed of this risk preprocedure, particularly if the cyst has a history of manipulation, infection, or previous excision.

Scarring/adhesions

When a cyst has been previously manipulated, inflamed, or partially excised, the potential for scarring, adhesions, and multiloculated cyst formation are increased. These characteristics make the cyst more difficult to completely identify intraoperatively, and may necessitate a wider excision.

Histology/misdiagnosis

Solid tumors may masquerade as a typical epidermal cyst. Proliferating pilar tumors often mimic pilar cysts, and even though they are usually benign, malignant transformation with local invasion and metastasis has been described.¹⁷ If a solid tumor is suspected during minimal excision, it should be removed en bloc and sent for pathologic evaluation. Regardless of technique used and degree of clinical suspicion, all cysts that are removed surgically should be sent for histopathology.

CONCLUSIONS

Dermatologic surgeons are frequently called upon to remove cysts, which present a common patient complaint. Proper patient selection and preoperative management may be invaluable in selecting the ideal candidates for surgical intervention. Several fundamental techniques are available to the dermatologic surgeon, from small punch excisions of simple cysts to wide elliptical excisions of previously inflamed or manipulated cystic masses. Additionally, the differential diagnosis of subcutaneous cystic nodules remains broad, and malignant mimickers must be always considered.

Surgeons should be particularly alert to rapidly growing cystic masses, which may be a harbinger of malignancy, and should always be removed.

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CHAPTER 51 Acne

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SUMMARY

- Acne is a common problem, and concerns regarding topical antibiotic usage, coupled with an increase in antibiotic resistance, have made surgical and procedural approaches to acne more attractive.
- Surgical approaches may address primary acne lesions or post-acne scarring.

Beginner Tips



- Inflammatory acne may be treated with chemical peels or laser and light-based approaches.
- Intralesional triamcinolone may be used in very low concentrations on a very occasional basis for select inflammatory papules and nodules, but its use is limited by the side-effect profile.

Expert Tips



- Intralesional corticosteroids may be injected directly through the top of inflammatory acne lesions.
- Ablative fractional laser resurfacing may be useful for acne scarring, and provides much of the benefit of ablative laser therapy with minimal risk of dyspigmentation or scarring.

Don't Forget!



- Many acne patients are of child-bearing potential; intralesional injections, chemical peels, and most other invasive treatments should probably be avoided in patients who may be pregnant.

Pitfalls and Cautions



- Aggressive use of intralesional corticosteroids may cause significant atrophy and telangiectasias.
- Patient education regarding postprocedure sun protection for PDT is critical.

Patient Education Points

- Patient expectations should be carefully managed, as an understanding of the expected degree of improvement will help mitigate the risk of disappointment and frustration.
- Acne is a chronic condition, and no treatment will lead to definitive cure; explaining this to patients may help control expectations.

Billing Pearls



- With the exception of intralesional injections, most surgical and procedural treatments for acne are not covered by insurance in the United States.
- Since many treatments require multiple visits, offering patients a discounted rate for multiple treatment packages may encourage compliance.

CHAPTER 51 Acne

INTRODUCTION

Acne is a multifactorial disease, caused by increased sebaceous gland activity, follicular hyperkeratinization, changes in immunological response, and obstruction of the infundibulum.¹ Retinoids or antibiotics are typically considered first-line treatment options, and work by exerting anti-inflammatory effects and attacking *Propionibacterium acnes* (*P. acnes*). However, the numerous side effects and growing antibiotic resistance associated with these approaches, coupled with a small but important subset of patients who fail to respond, highlight the need for procedural therapies.²

Despite the advent of light and heat therapies, comedone extraction and intralesional injection remain in vogue, due in part to their significant efficacy. Recently however, techniques such as photodynamic therapy (PDT) have increased in popularity due to both their efficacy and safety profile.

PHYSICAL REMOVAL AND ELECTROSURGERY

In 1900, Thibierge introduced the extraction of comedones as the first physical therapy for acne treatment.³ While this method results in immediate improvement, it is associated with a risk of tissue damage and the possibility of incomplete extraction. Lowney et al. showed that comedone extraction reduces the recurrence rate of inflammatory comedones, while exacerbating inflamed cystic lesions. In another study, Pepall et al. used light cautery to treat macro-comedones. They reported 95% lesion clearance with no adverse effects of scarring or pigmentation. Only a few other studies

investigated the efficacy of fulguration and cautery, with overall results showing that fulguration results in more noninflammatory lesion improvements compared to topical tretinoin. These studies also show that fulguration provides the same satisfactory results as electrocautery, and most patients prefer fulguration.³⁻⁵

INTRALESIONAL STEROID INJECTION

Since 1952, intralesional corticosteroid injections have been considered an effective acne treatment method, especially after topical and oral treatments have failed or when a rapid response is necessary. Steroid injection can be used as monotherapy or in combination with other treatments for nodular and cystic acne, which may result in nodules flattening in 2 to 3 days (Table 51-1).^{6,7} This method works by maintaining a high steroid concentration at the acne papule or nodule while minimizing systemic absorption in order to prevent adverse reactions. At the molecular level, the steroid–receptor complex within the target cell binds glucocorticoid response elements, directly affecting gene transcription. Injection with corticosteroids exerts anti-inflammatory effects and enhances the production of certain prostaglandins and leukotrienes.⁷

Table 51-1. Treatments for Nodular and Cystic Acne

Method	Reference	Number of Patients	Number of Treatments	Acne Type	Results	Side effects
Cryotherapy and intralesional corticosteroid injections	Yosipovitch et al. (2001)	10	3 treatments at 4-week intervals	Keloid scars	Better responses with combined cryotherapy and triamcinolone vs. monotherapy (in terms of keloid thickness)	No significant side effects Itch was lowered with combined therapy
Microdermabrasion and 1,450-nm diode laser	Wang et al. (2006)	20	4 treatments every 3 weeks	Active inflammatory acne Fitzpatrick skin types II–IV	No increased clinical efficacy or decreased pain in combination therapy vs. laser or microdermabrasion alone (mean reductions of 53.5% and 55.6% for laser alone and combination therapy, respectively)	Same for laser alone and laser plus microdermabrasion Mild erythema, mild edema, and small papules
Mixed blue and red light (peaks at 415 and 660 nm)	Papageorgiou et al. (2000)	107	12 weeks	Mild to moderate acne vulgaris	Mean 76% improvement in inflammatory lesions (significantly more than blue or white light alone) and mean 58% improvement in comedones	No significant short-term adverse effects (minor facial rash and dryness) and no significant difference between the treatment groups
Blue and red light combination LED	Lee et al. (2007)	24	Twice a week for 4 weeks	Mild to moderately severe facial acne Fitzpatrick skin type IV	Mean improvements of 34.28% and 77.93% in noninflammatory and inflammatory acne, respectively (as efficient as ALA-PTD)	No side effects
IPL laser with ALA ^a	Mei et al. (2013)	41	4 treatments at 1-week intervals	Moderate to severe facial acne	Mean reduction of 83.6% and 57.5% in inflammatory and noninflammatory lesions, respectively	Transient erythema and monomorphic acneiform eruptions (IPL plus ALA group) Pricking pain (IPL)
IPL with MAL	Yeung et al. (2007)	30	4 treatments at 3-week intervals	Moderate acne Skin types IV or V	65% mean reduction of the inflammatory lesions compared to 23% for IPL alone (however, no significant difference was observed between the control group and PTD group) Delayed but significant reduction of noninflammatory lesions in both the PDT and IPL groups.	25% of patients in the PDT group withdrew due to: stinging, burning, erythema, edema, crusting, hyperpigmentation, and transient acneiform flares No significant difference in pigmentation, atrophy, and scarring between the IPL group and the PTD group
Blue light (Blu-U, 417 nm) with ALA	Goldman and Boyce (2003)	22	Once a week for 2 weeks	Mild to moderate inflammatory acne vulgaris	32% improvement vs. 25% for blue light alone treatment group	No serious side effects and pain free
Red light with ALA ^b	Hongcharu et al.	22	Single treatment and multiple treatment groups (once a week for 4 weeks)	Mild to moderate acne vulgaris	Clinical and statistically significant clearance of inflammatory acne for at least 20 weeks after multiple treatments and 10 weeks after a single treatment	Painful, pruritic Causes acute erythema and edema, occasional blistering, an acute acneiform eruption, and hyperpigmentation that fades gradually
Diode laser with indocyanine green (ICG) ^c	Seo et al. (2016)	47	3 or 5 treatments every 2 weeks	Acne vulgaris Fitzpatrick skin types III–V	Five ICG-PDT treatment sessions caused a greater reduction of papules/pustules compared to three sessions	Mild erythema
Diode laser with gold coated silica microparticles (Selective photothermolysis)	Paithankar et al. (2015)	50	3 treatments at 2-week intervals	Moderate to severe inflammatory facial acne Fitzpatrick skin phototype I–III	Clinically and statistically significant improvement of inflammatory acne	Erythema and perifollicular edema
Diode laser at 1,450 nm wavelength and cryogen cooling	Paithankar et al. (2002)	27	4 treatments at 3-week intervals	Inflammatory and noninflammatory acne lesions	Significant reduction ($p < 0.01$) in lesion counts	Erythema, edema and hyperpigmentation
595-nm pulsed-dye laser (PDL) with 1,450-nm diode laser	Glaich et al. (2006)	15	Every 4–6 weeks	Active inflammatory acne vulgaris Fitzpatrick skin types II–IV	Mean lesion count reduction of 84% after 3 treatments and improvements in acne scarring Faster response time compared to each laser alone	Mild erythema
Ablative fractional laser resurfacing (AFR CO ₂) and nonablative laser resurfacing (1,064-nm long-pulse Nd:YAG laser)	Kim and Cho (2009)	20	3 monthly treatments	Mild to severe acne scar	The combination of lasers yielded better results compared to the ablative fractional laser alone	Less when using the combination method (erythema, crusts, and hyperpigmentation)
Photopneumatic technology and profusion	Narurkar et al. (2013)	41	4 treatments at 1–2-week intervals	Mild to moderate acne Fitzpatrick skin types I–VI	69% reduction in inflamed acne lesions and 41% reduction in noninflamed acne lesions	Mild erythema
Radiofrequency and pulsed light	Prieto et al. (2009)	32	Twice weekly for 4 weeks	Moderate inflammatory acne Fitzpatrick skin types I–VI	Mean lesion count reduction of 47%. 59% of the patients labeled their improvement as “good”	Mild erythema, tingling, and burning

Salicylic acid chemical peel and PDL ^d	Lekakh et al. (2015)	19	3 treatments at 3-week intervals	Moderate to severe acne	Significant improvement in both the combined therapy and chemical peel alone treatment groups with significantly greater improvements in the combination treatment group	NR
5-FU with intralesional corticosteroids (TAC) and PDL	Manuskiatti and Fitzpatrick (2002)	10	6 treatments at 4-week intervals (PDL and TAC) Every 2 weeks for the first 8 treatments and every 4 weeks for the last 2 (5-FU)	Keloidal or hypertrophic scars	Intralesional injections reduced the treatment duration and resulted in rapid improvement compared to treatment with the PDL alone	Intralesional corticosteroid is more likely to cause adverse effects Transient burning sensation and purpura
Focal chemical peeling, CO ₂ laser, scar excision, punch grafting, and dermabrasion ^e	Whang and Lee (1999)	32	1 and 3 times monthly	Acne scars	Excellent or good results for 75% of patients with various scars	Hyperpigmentation, erythema, and hypertrophic scars (in 1 patient)
Dot peeling, subcision, and fractional laser irradiation ^f	Kang et al. (2009)	10	Twice in 2-3-month intervals (dot peeling and subcision) Every 3-4 weeks (laser)	Acne scar Fitzpatrick skin type IV or V.	80% of the patients reported significant improvement Acne scar severity score reduction by 55.3%	No cases of significant complications

^aMei X, Shi W, Piao Y. Effectiveness of photodynamic therapy with topical 5-aminolevulinic acid and intense pulsed light in Chinese acne vulgaris patients. *Photodermatol Photoimmunol Photomed*. 2013;29(2):90-96.

^bHongcharu W, Taylor CR, Chang Y, Aghassi D, Suthamjarinya K, Anderson RR. Topical ALA-photodynamic therapy for the treatment of acne vulgaris. *J Invest Dermatol*. 2000;115(2):183-192.

^cSeo HM, Min HG, Kim HJ, et al. Effects of repetitive photodynamic therapy using indocyanine green for acne vulgaris. *Int J Dermatol*. 2016.

^dLekakh O, Mahoney AM, Novice K, et al. Treatment of acne vulgaris with salicylic acid chemical peel and pulsed dye laser: a split face, rater-blinded, randomized controlled trial. *J Lasers Med Sci*. 2015;6(4):167-170.

^eWhang KK, Lee M. The principle of a three-staged operation in the surgery of acne scars. *J Am Acad Dermatol*. 1999;40(1):95-97.

^fKang WH, Kim YJ, Pyo WS, et al. Atrophic acne scar treatment using triple combination therapy: dot peeling, subcision and fractional laser. *J Cosmet Laser Ther*. 2009;11(4):212-215.

Triamcinolone derivatives are widely used for intralesional injections because of their low-pain administration and longer duration of action. Triamcinolone acetonide is often diluted to 5 or 3.3 mg/mL for use on the face, although dose and injection intervals may vary according to the type and size of the lesion. Advantages of intralesional triamcinolone acetonide injection include its simplicity, affordable cost, and limited side-effect profile, though possible side effects include atrophy, dyspigmentation, and telangiectasias.⁷⁻⁹

Although intralesional triamcinolone injections are traditionally administered by inserting the needle into the target area, Lee et al. suggested inserting the needle through the pore, bypassing intact skin. This method may result in less pain, bleeding, and atrophy.⁹ Intralesional injections are best used for an occasional or particularly stubborn cystic lesion.⁸

Levine and colleagues explored the minimum dosage of intralesional steroids required to be effective for nodulocystic acne treatment and found that very low concentrations of triamcinolone acetonide (0.36 mg/mL) are not only as effective as higher concentrations, but also reduce the risk of atrophy and pigmentary changes.⁶

CRYOTHERAPY

A study by Karp et al. evaluated cryotherapy as a modality for acne treatment. In their study, a mixture of solid carbon dioxide, acetone, and precipitated sulfur was applied to a lesion for 20 minutes. This combination led to mild exfoliation, erythema, and edema.¹⁰ A comparative study further demonstrated that liquid nitrogen may improve pustular, but not comedonal or papular acne, and is most effective for superficial lesions.¹¹ In addition, liquid nitrogen has been shown to reduce keloid volume in 80% of acne scars, with a combination of cryotherapy and intralesional corticosteroid injections reportedly providing a more significant response.^{12,13}

Cryotherapy is associated with a significant risk of hypopigmentation, and patients should be advised that it may take several weeks for the resulting erythema to resolve.^{14,15}

MICRODERMABRASION

Microdermabrasion removes the stratum corneum, resulting in the stimulation of dermal fibroblasts and epidermal renewal.^{16,17} Most microdermabrasion units consist of closed-loop negative pressure systems that pass aluminum oxide crystals into the skin; sodium chloride crystals and positive pressure are also used.¹⁸

This method has limited scientific data to support its efficacy. Although microdermabrasion may assist light penetration when used in conjunction with light-based therapies, one study reported that microdermabrasion used in conjunction with a 1,450-nm diode laser did not enhance the effect of laser for treatment of inflammatory acne, although the absorption of topical medications was increased when used with PDT.^{19,20}

CHEMICAL PEELS

Glycolic- and salicylic acid–based chemical peels are another approach to treating inflammatory and comedonal acne, and may be beneficial for postinflammatory hyperpigmentation.²¹ Salicylic acid is a chemical peeling agent effective against inflammatory lesions, and can easily penetrate the pores of the skin due to its high lipophilicity.²² However, maintenance

treatments are necessary for chemical peels to have a long-lasting effect. Patients have reported a higher satisfaction rate with chemical peels compared to microdermabrasion.²³

LASERS AND LIGHT-BASED THERAPY

Increased antibiotic resistance to *P. acnes* and adverse effects of retinoids and antibiotics have led to the growing demand for light-based therapy. *P. acnes* contain endogenous porphyrins which can be targeted through visible light (with an absorption peak of 415 nm), resulting in destruction of the bacteria.²⁴

Light emitting diodes (LEDs) are a popular phototherapeutic modality, and 670-nm LED therapy has been described for the induction of rapid wound closure and tissue regeneration, while downregulating cytokine-encoding genes. Several other studies have attributed various success rates to phototherapy using blue light. For example, Morton et al. reported the efficacy of a blue light source on inflammatory acne lesions. The results showed a mean 34% improvement in noninflammatory lesions and a 78% improvement in inflammatory lesions.²⁵

Lee et al. conducted a study to evaluate the success rate of phototherapy using blue and red light sources (which peak at 415 and 633 nm, respectively) on mild to moderately severe facial acne. They reported that after the therapy, moisture and sebum levels decreased only slightly while the melanin level showed a significant decrease. Although not offering significant clinical improvement, this treatment may have a brightening effect on skin tone.²⁶

In another study by Papageorgiou et al., a combination of blue and red light from fluorescent lamps resulted in a mean improvement of 58% in comedones and a 76% improvement in inflammatory lesions,²⁷ highlighting the possible advantage of a mixed light approach as opposed to blue light alone. This may be due to the combination of antibacterial and anti-inflammatory properties of blue and red light, respectively.²⁶

Studies have also addressed the positive effects of red light therapy, with one in vitro study demonstrating that red light affects cytokine release from macrophages, stimulating fibroblast proliferation.²⁸ According to another

study by Karu, red light absorption can alter the redox status of the respiratory chain components and consequently stimulate cellular proliferation.²⁹

Overall, light-based acne therapy is currently growing in popularity, and its effects can be divided into three groups: photochemical, photothermal, and a combination of both. Alternatively, light-based therapy can be categorized according to its target, such as *P. acnes*, the follicular infundibulum, and the sebaceous glands.³⁰

Blue and red light

Studies have also addressed blue and red light's ability to improve acne lesions. The photochemical effect is a cascade of chemical reactions following the absorption of light into the chromophores that occurs without tissue destruction. In contrast, the photothermal effect aims to increase the chromophore temperature, with longer-energy exposures that cause cellular vaporization.

Blue light penetrates the skin to less than 100 microns, though at 407 to 420 nm, blue light also carries the strongest porphyrin photoexcitation coefficient. When the endogenous porphyrins in *P. acnes* absorb light at a specific wavelength, they initiate a phototoxic reaction to destroy the bacteria. This chemical process suggests that blue light carries the optimal wavelength to induce phototoxicity in *P. acnes*.^{31,32}

Red light penetrates to the level of the sebaceous glands, and has a photothermal effect on sebaceous glands while also stimulating cytokine release from macrophages.³³ The combination of both lights can be superior to the use of either alone due to the bactericidal effects of the blue light and the anti-inflammatory effects of red light.³⁰

Pulsed-dye laser

Pulsed-dye laser (PDL) acts through a photochemical effect on porphyrins, resulting in phototoxication and a concomitant photothermal effect on sebaceous glands.³⁰ PDL upregulates transforming growth factor beta (TGF-beta), thereby mediating an anti-inflammatory response within the body.³⁴

To date, 14 studies have focused on the use of PDL for acne treatment, 5 of which have combined PDL with a topical agent, such as 5-aminolevulinic acid (ALA). Improvement of inflammatory lesions ranged between 30% and 80% in these studies. However, when PDL was used alone, a significant reduction in inflammatory lesions was reported for four out of six studies.³⁰

The effectiveness of combining PDL (585 nm) and diode laser (1,450 nm) has been shown for mild to moderate inflammatory acne with a mean lesion count reduction of 84% after three treatments. This improvement is not only seen in acne, but also in acne scarring. Adverse effects of this approach include mild erythema and pain, which can be controlled with topical anesthetics. After the first treatment, a reduction of 37% was reported with the diode laser alone, while a 52% reduction was achieved with both lasers combined. Thus, the combined approach results in a more rapid response. The proposed mechanism of action for diode and PDL lasers entails shrinkage of the oil glands and reduction of *P. acnes*.³⁵ A firm consensus on the efficacy of PDL for acne treatment has not yet been established.³⁰

Intense pulsed light

The intense pulsed light (IPL) device generates a strong, polychromatic, and noncoherent light. IPL is used in acne treatment for the photochemical effect of the blue and red light range and the photothermal effect of the infrared light range on porphyrins and inflammatory cells, in addition to heating the sebaceous glands.³⁶ In a split-face controlled clinical trial, inflammatory and noninflammatory lesions were reduced with IPL compared to no treatment.³⁷ Another study reported clearance rates as high as 72% after 6 months.³⁸ Overall, IPL may be superior to blue and red light, although it may be less effective than PDL.³⁰

PDL, IPL, and LEDs have been compared in the treatment of patients with moderate to severe acne. The results favor IPL, which achieved a 90% inflammatory lesion clearance at a faster rate.³⁹

Potassium titanyl phosphate

A potassium titanyl phosphate (KTP) laser emits green light and has a higher penetration coefficient than blue light. This laser operates based on porphyrin activation and a photothermal effect on the sebaceous gland. However, the KTP laser effect on acne is not long-lasting and may lead to erythema, edema, and transient crusting. Therefore it is not widely used for the treatment of acne.³⁰

Ablative Lasers

Ablative lasers target water as the main chromophore in the sebaceous gland, thereby halting sebum production. Four studies have evaluated the use of the 1,540-nm Erbium glass laser, a mid-infrared laser resulting in 73% acne reduction after a 2-year follow-up. No significant side effects were associated with the use of this laser.⁴⁰

Another study evaluated a diode laser (1,450 nm) used in combination with cryogen spray cooling to target the sebaceous glands. The cooling effect of the cryogen protects the epidermis from thermal damage, allowing the heat to only affect the sebaceous glands. A reduction of acne lesions after a single session has been reported, with side effects ranging from transient erythema to edema.⁴¹ Though several studies have reported that the 1,450-nm diode laser is effective for treating inflammatory lesions, it may be less than ideal in practice given the significant pain associated with its use.³⁰

Photodynamic therapy

PDT uses a photosensitizing agent, such as ALA, methyl aminolevulinate (MAL), or indole-3-acetic acid (IAA). These photosensitizing agents become absorbed by the pilosebaceous unit and augment its response to a light source. The use of photosensitizing agents results in the production of free radicals in the epithelium and pilosebaceous unit, leading to *P. acnes* destruction. Light sources commonly used in PDT include diode lasers, near-infrared diode lasers, and other lasers with outputs in the visible light range, such as IPL, LEDs, blue light, and red light.⁴² One study showed that *P. acnes* cultures grown in the presence of ALA led to a fivefold decrease in culture viability after three illuminations of high-intensity blue light.⁴³ Furthermore, treatment of inflammatory lesions with PDT may increase acne clearance by

42% compared to IPL alone at 12-week follow-up.⁴⁴ Several other split-face trials have also reported a higher reduction in lesions when treated with PDT than when treated with light therapy alone. The use of ALA, in conjunction with IPL and MAL, in conjunction with PDL, have been examined, with studies showing greater improvements when the photosensitizing agent is used in combination with the light source. In addition to red light, blue light has also demonstrated efficacy when used in combination with ALA.^{44,45} As a lipophilic derivative of ALA, MAL has better penetration properties. Two studies evaluating the efficacy of MAL found modest improvements.^{46,47}

The use of ALA and red light may result in a transient acne-like folliculitis and reduced sebum secretion after 20 weeks of PDT therapy.⁴² ALA and red light ultimately led to statistically significant clearance rates for inflammatory acne. Despite its efficacy as a treatment, major side effects were observed, including phototoxicity to the sebaceous follicles and prolonged inhibition of sebaceous gland activity. PDT sessions in 23 patients were accompanied by acute erythema, edema, and an acute acneiform eruption, with occasional side effects consisting of vesicle formation, purpura, and hyperpigmentation.⁴² PDT is not generally considered a first-line treatment for acne, though it may be useful for severe nodulocystic acne recalcitrant to other treatments as an alternative to isotretinoin.⁴²

Photopneumatic therapy

The photopneumatic technique involves pneumatic energy and broadband light (400–1,200 nm). With the help of suctioning, the dermis is brought upward toward the skin's surface permitting more efficient energy absorption. This method lowers the risk of pigmentary changes. Photopneumatic therapy (PPX) operates based on thermal and vacuum physics effects. The suctioning creates negative pressure, which assists in the removal of comedones. This novel approach utilizes mechanical extrusion, along with photothermal and photochemical reactions, to treat mild to moderate acne.⁴⁸

One study reported 90% clearance after four treatment sessions, in which a single session resulted in 50% clearance. PPX results in the extrusion of comedone contents from the infundibulum while decreasing sebaceous gland

activity through its thermal effect. Further study is needed to better elucidate the role of PPX in acne treatment.⁴⁹

Targeted photothermolysis with exogenous chromophores

A light-absorbing chromophore is introduced into the sebaceous follicles and exposed to optical pulses, inhibiting overactive sebaceous glands and hyperkeratinizing cells of the infundibulum.¹ Since there are no indigenous chromophores that can absorb the optimal wavelength range of 425 to 550 nm, the sebaceous glands are loaded with a specific exogenous chromophore prior to laser treatment. For example, selective photothermolysis of sebaceous glands with topical indocyanine green (ICG) as a chromophore activated with a diode laser resulted in acne improvement.⁵⁰

Directly heating the area where *P. acnes* grows can also result in the reduction of bacteria in the follicle. In optical-particle–assisted selective photothermolysis, light-absorbing particles are used as mediators for selective photothermolysis of sebaceous follicles. These particles penetrate the infundibulum and sebaceous follicles via vibratory massage. In one study, the particles used were gold-covered silica, and upon exposure to an 800-nm diode laser, the glands were thermally injured. Utilizing particles that exhibit plasma resonance subsequently alleviated inflammatory acne. Further study is needed before these approaches are adopted widely.¹

Radiofrequency

Radiofrequency (RF) is a novel treatment method that heats the tissue through electric currents, instead of photon absorption. The energy resulting in selective thermal injury in this method is not absorbed by melanin. When pulsed light and RF are used in combination, adverse effects such as superficial blisters, burns, pigmentation disorders, and scarring are reduced, as optical energy is minimized while RF energy is kept high. One study reported improvement in inflammatory lesions through reducing the size of the sebaceous glands and quantity of perifollicular lymphocytic infiltrates.⁵¹ A more recent approach has been used to deliver high-intensity RF by

insulated microneedles, which result in deep thermal injury to layers of dermis without affecting the epidermis. Thus, energy can be focused on multiple depths of the dermis for all skin types.⁵²

Overall, RF has been used as a single nonablative device in two acne treatment studies. The results of both studies suggest that RF offers a promising nonablative treatment alternative for acne, although further investigation is necessary to provide information concerning effective protocols, duration of efficacy, and reproducibility of results.⁸

While there is evidence to support the efficacy of light-based therapies, it is difficult to draw conclusions and firmly rank each method with regard to efficacy due to mixed results in the literature, methodological limitations, and small sample sizes. Thus, more randomized controlled trials with larger sample sizes are needed to better assess the merits of light-based therapy.³⁰

MANAGEMENT OF ACNE SCARRING

Healing acne lesions may result in scar formation, especially when preceded by episodes of severe inflammatory nodulocystic acne. Although isotretinoin can be used to prevent acne scarring, in addition to inflammation, 95% of acne patients still develop scarring.^{53,54} While such scars can be permanent, laser and surgical treatments can alleviate the condition. Patients prone to scar formation tend to show a stronger and longer-lasting nonspecific inflammatory response, and scarring may be seen even in cases of mild acne.⁵⁵ The first approach in the management of acne scarring involves prevention, with early acne treatment.⁵⁶ After scar formation occurs, treatment should be tailored to the patient's individual needs.

In order to treat acne scars, it is important to identify the scar type, effectively perform the procedure, and know the side effects and efficacy of each treatment option.

The three main types of acne scars include keloid scars, hypertrophic scars, and atrophic scars.⁵⁷ Keloids and hypertrophic scars may be effectively treated with intralesional corticosteroids, and their management is detailed in [Chapter 49](#).^{55,57}

Dermabrasion

Dermabrasion removes the epidermis and part of the dermis, resulting in reepithelialization and repigmentation of adnexal structures, and can be useful for softening scar edges. This technique may be performed with a rotating hand piece attached to a wire brush or serrated wheel, diamond-embedded fraises, or handheld sterilized sandpaper.⁵⁸ Local anesthesia is usually required with this method due to the severe pain involved.⁵⁹ Deep scars, such as ice pick scars, cannot be treated successfully with this procedure, though atrophic scars, such as rolling or boxcar scars, can be treated quite effectively.^{60,61}

One study compared diamond-fraise dermabrasion to fractionated CO₂ laser. No significant difference was reported between the techniques, although significantly fewer adverse effects were attributed to laser therapy.⁶² Important drawbacks of dermabrasion include photosensitivity, erythema lasting several weeks to several months, and hypopigmentation.⁵⁹ A risk of dermabrasion is hypertrophic scarring after the procedure, which has been seen in patients undergoing dermabrasion following isotretinoin therapy. Thus, a 6-month waiting period is recommended prior to dermabrasion after taking isotretinoin.^{63,64} Dermabrasion is technique dependent, and has been partly replaced by resurfacing lasers.^{64,65} For a more extensive discussion of dermabrasion, see [Chapter 56](#).

Soft-tissue augmentation

Patients with superficial atrophic scars may benefit from soft tissue augmentation.

Hyaluronic acid, calcium hydroxyapatite, and poly-L-lactic acid containing products may improve acne scarring, although little data are available for hyaluronic acid for the treatment of acne scars in the literature.⁵⁵

Fat transfer

In autologous fat transplantation, adipose grafts are used for soft-tissue augmentation, and may benefit from the subcision of acne scars. More than one transfer procedure is often necessary, as fat survival is not complete and is technique and patient dependent. One study suggested that one session of fat transfer is more effective than three sessions of fractional CO₂ laser, though follow-up times were short.^{66,67}

Autologous fibroblast transfer

Autologous fibroblast transfer (AFT) is a novel technique that may result in permanent acne scar improvement and has low allergenicity. Here, after punch biopsies are performed in an inconspicuous site, fibroblasts are separated and cultured for several weeks. The acne scar is then injected with the fibroblasts in order to promote collagen formation. AFT has been shown to result in significant improvement compared to placebo, while incurring minimal side effects such as erythema and edema, though further study is needed.^{67,68}

Punch excision

Punch excision may be used to remove deep pitted scars, such as ice pick scars, by excising scar tissue and resuturing; this leads to a subtle and ideally non atrophic scar.⁶⁹ This approach may be followed by laser resurfacing or dermabrasion for optimal results. Punch grafts can also be taken from posterior auricular skin for deep scars, which may be a suitable choice for ice pick scars.⁵⁵

Punch elevation is a combination of excision and grafting methods, in which a punch biopsy tool is used to remove the base of the scar, while leaving the walls intact. Punching the base of the scar makes the base parallel to the outer walls, elevating the scar base and reducing its depth.⁷⁰ The elevated skin can then be positioned evenly via sutures or Steri-Strips. This technique is most suitable for deep boxcar scars with sharp borders and less than 3 mm of depression.^{71,72}

Laser resurfacing can enhance the effect of punch excision combined with either grafting or elevation. Punch excision used together with CO₂ laser

resurfacing has been reported to result in significant improvement.⁵⁵ Ablative laser treatment alone may lead to improvement rates ranging between 25% and 90% for atrophic scars. Disadvantages include a large time commitment and cost.⁷³ Nonablative fractionated lasers have fewer side effects and a respectable success rate for atrophic scars.⁵⁵

Subcision

Subcision is another treatment option for rolling scars.⁷⁴ This procedure can be performed with a filter needle that penetrates the subdermal plane, destroying the scar through forward and backward motion and horizontal rotation of the needle. The motion loosens the fibrotic adhesions that give a bound-down appearance to rolling scars, creating a wound susceptible to collagen deposition. Moreover, loosening the fibrous attachments makes the scars more responsive to other treatments, and promotes neocollagenesis.⁷⁰

Skin needling

Skin needling, also referred to as collagen induction therapy (CIT) also enhances neocollagenesis. Scar tissue is removed in this procedure by vertical puncturing of the skin. The tools used for this purpose include a rolling barrel with rows of needles. Rolling the device on the skin to achieve 0.1- to 1.3-mm penetration creates holes similar to the way fractional ablative lasers create “noncontiguous columns of thermal injury, with healthy tissue interspersed to promote healing.”⁶⁷

Chemical peels

Medium-depth peels such as those using trichloroacetic acid (TCA) may have unpredictable penetration. For deep peels, one study using phenol showed an improvement of greater than 50% in 7 out of 11 patients.

However, long-lasting adverse effects were also reported.⁷⁵ High concentration TCA has also been studied; patients were treated with either 65% or 100% TCA, and more than half of the patients in both groups showed significant improvement. In addition, multiple treatments using 100% TCA

resulted in more than 70% improvement.^{76–78} In one study comparing the effects of 100% TCA to the effects of skin needling, the improvement rates were 75.3% and 68.3%, respectively, after four sessions.⁷⁹

Laser resurfacing

Laser resurfacing is frequently used for acne scar treatment with both ablative CO₂ and Er:YAG lasers, at 10,600 and 2,940 nm, respectively. Water in the skin absorbs the infrared wavelengths generated by these laser devices, leading to destruction and ensuing collagen formation. Ablative CO₂ lasers have been shown to result in 81% improvement in moderate to severe acne scars.⁸⁰ The negative effects of these lasers include dyspigmentation, erythema, fibrosis, and scarring. Laser resurfacing may not be ideal for dark-skinned patients, though single-pass CO₂ laser can reduce the intensity and duration of hyperpigmentation compared to a multi-pass procedure.⁸⁰

Although nonablative lasers, such as the long-pulsed 1,450-nm diode and 1,320-nm Nd:YAG are safer than ablative lasers, they generally provide only modest benefit over three to six sessions.⁶⁷ A 1,550-nm erbium-doped laser was assessed for ice pick, boxcar, and rolling scars. After five treatments the mean improvement ranged from 25% to 50%. The improvement was achieved without scarring or dyspigmentation, although erythema and edema were observed.⁸¹

The largest study on nonablative fractional lasers (NAFL) to date was conducted on 500 patients, using a 1,540-nm-fractional laser. After three treatments, the median improvement ranged from 50% to 75%.^{82,83}

Several studies have revealed that ablative fractional lasers (AFL) confer the additional advantage of prolonging collagen remodeling. One study found that two to three monthly treatments with fractional CO₂ can lead to a 66.8% mean improvement based on topographic analysis. Although local side effects were still observed, they disappeared within a week. The most important advantage of this technique was that no pigmentary changes occurred, in contrast to using fully ablative resurfacing modalities.⁸⁴ However, AFL used at low-energy settings, along with nonablative 1,064-nm Nd:YAG, can result in a higher percent improvement with fewer side effects compared to using AFL alone.⁸⁵ In one study, NAFL was compared to AFL,

in which atrophic scars showed equal or greater improvement with AFL treatment. Thus, AFL provides much of the efficacy of ablative lasers without the risk of scarring or dyspigmentation.⁸⁶

Intralesional corticosteroids

Intralesional corticosteroid injections are considered first-line therapy for both keloids and hypertrophic scars.^{42,87} When injected into the skin, steroids decrease fibroblast proliferation and collagen synthesis while reducing inflammatory mediators. Hypertrophic scars are injected every 4 to 6 weeks with 10 mg/mL triamcinolone, depending upon the depth of the scar. Side effects include hypopigmentation, atrophy, and telangiectasias. The success rate for triamcinolone acetonide is more than 50%, with lower recurrence rates.⁵⁵ Of note, over-treatment with intralesional corticosteroids can cause skin atrophy, and two studies have demonstrated that oral and topical retinoids may alleviate the atrophy associated with scar over-treatment.^{88,89}

Cytotoxic agents

Intralesional administration of cytotoxic agents, such as fluorouracil (5-FU) and bleomycin, serves as an alternative treatment option for hypertrophic scars and keloids.⁵⁵ 5-FU prevents proliferation of fibroblasts in dermal wounds, and some evidence suggests its efficacy for facial acne scars.^{55,90} Augmenting 5-FU with intralesional corticosteroids and a 585-nm PDL can also yield satisfactory results. A randomized control trial compared the response rate to intralesional corticosteroids alone or combined with 5-FU and 585-nm PDL. While no significant difference was apparent between the groups, all groups showed high success rates. In addition, intralesional injections reduced the treatment duration, and showed more rapid improvement compared to treatment with the PDL alone.⁹¹

Disadvantages of 5-FU administration are pain and purpura, although it has been proposed that combining 5-FU with either a corticosteroid or lidocaine can alleviate these side effects. The dose of 5-FU used in several studies falls between 50 and 150 mg per session. In order to increase the

efficacy of this method, the recommended dose can be administered more than once a week.⁹²

Radiation

Radiotherapy reduces fibroblast activity and induces cellular apoptosis, inhibiting the recurrence of keloidal scars, and making it an effective adjuvant to surgical excision.⁹³ Surgical excision is associated with recurrence rates, ranging between 45% and 100%, but this rate can be reduced to 10% via perioperative radiation.⁵⁵ For a more extensive discussion of radiation therapy, see [Chapter 37](#).

CONCLUSIONS

Acne is a common problem, and dermatologic surgeons may approach these patients in several ways. Options range from laser and light devices for primary acne lesions to scar revision, chemical peels, dermabrasion, and needling for acne scars. Further studies comparing the efficacy of various therapeutic modalities may help better determine an ideal treatment approach, though multimodality treatment options may ultimately provide the highest success rates.

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CHAPTER 52 Vitiligo

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SUMMARY

- Vitiligo surgery is an effective treatment modality in patients with stable disease who have failed medical management (except for focal and segmental vitiligo, in which surgery is a first-line option), and do not have perioral or distal fingertip involvement.
- Surgical techniques in vitiligo are broadly classified as either tissue or cellular grafts.

Beginner Tips



- Indicators of a favorable response include stable disease, focal and segmental vitiligo, and facial, neck, and truncal involvement.
- Indicators of an unfavorable response include unstable disease, nonsegmental vitiligo, isolated scalp leukotrichia, and lesions affecting the extremities, distal fingertips, periorificial areas, and joints.
- STSG is the most effective surgical technique for establishing repigmentation in small patches of vitiligo, but it does have limitations.

Expert Tips



- For larger patches of vitiligo, NCES is the most effective treatment option, with the largest number of supporting clinical trials available.
- Adjuvant treatments such as topical immunomodulators, oral corticosteroids, oral antioxidants, phototherapy, and additional surgeries may be necessary after vitiligo surgery to optimize treatment outcomes.

Don't Forget!



- The size and location of the surgical site, clinical resources, and the risks and benefits of each method should be carefully considered when selecting a surgical technique.
- The Q-switched ruby laser, Q-switched alexandrite laser, and Q-switched Nd:YAG laser are effective modalities for laser-mediated depigmentation in vitiligo.

Pitfalls and Cautions



- Micropigmentation is generally *not* recommended for camouflage due to associated long-term complications.
- All techniques involve possible risks of undesirable scarring, textural mismatch, and color mismatch.
- These techniques should be used only with extreme caution in patients with a history of keloid formation.

Patient Education Points



- Preoperatively, patients must understand that it may take months to years to achieve the full extent of repigmentation and color match, and that surgery is a treatment, not a cure for the disease.

Billing Pearls



- Although it has been shown to improve quality of life, vitiligo surgery is currently not covered by insurance in the United States, making it unavailable to many patients.

CHAPTER 52 Vitiligo

INTRODUCTION

Vitiligo is characterized by the development of depigmented macules and patches, and occurs through the mechanism of melanocyte destruction. Treatment focuses on repigmentation and disease stabilization using medical, light-based, and surgical therapies; though each of these approaches may be used independently, combination approaches are frequently utilized to optimize outcomes.

Surgical approaches are effective for select patients with vitiligo. Existing techniques in vitiligo surgery have undergone significant refinement and continue to evolve, with a focus on optimizing treatment outcomes as well as physician and patient satisfaction. Though relatively underperformed, vitiligo surgery has become increasingly popular due to the limitations of medical therapies for vitiligo.

PREOPERATIVE EVALUATION

Patient selection

Vitiligo surgery is typically considered after patients have failed conservative measures such as medical and light-based therapy. History and physical examination are used to determine a patient's vitiligo subtype. Vitiligo patterns are classified as segmental and nonsegmental, with generalized vitiligo being the most common variant of nonsegmental vitiligo. Segmental vitiligo is typically unilateral, in a localized region, and is considered stable, whereas generalized vitiligo is bilateral, symmetric, and follows a relapsing and remitting course.¹ Patients with focal or segmental

vitiligo have an excellent response to surgery, which is considered a first-line treatment option in these patients.² In contrast, patients with generalized vitiligo and other subtypes have a less favorable response to surgical intervention, though surgery remains an option in the setting of stable disease and a history of failed response to medical therapy.

Prior to attempting surgery, disease stability must be evaluated. The main criterion marking stable disease is the lack of new or enlarging lesions for a minimum of 6 months and up to 2 years. Koebnerization is a marker of unstable disease. Several methods are available to assess disease stability, including patient report, serial photography, and validated scoring systems. These include the Vitiligo Area Scoring Index (VASI), Vitiligo European Task Force Assessment (VETF), and Vitiligo Disease Activity Score (VIDA), the latter of which is appropriate in patients who have discontinued vitiligo treatment for at least 6 months.³

In patients with unclear disease stability, a single punch graft (typically 1–1.5 mm) can be performed in the center of a stable, depigmented lesion as a test spot to assess repigmentation, responsiveness to treatment, and healing tendency.⁴ A test is considered positive when repigmentation occurs beyond 1 mm and up to 2 to 3 mm from the minigraft border; a test is considered negative when less than 1 mm or no repigmentation occurs.⁴

Emerging methods to evaluate disease stability include reflectance confocal microscopy,⁵ total antioxidant status,⁶ antimelanocyte antibody levels, and measurement of serum catecholamines and their metabolites.⁷ Similarly, cellular markers such as IL-17,⁸ CXCL 9 and 10,⁹ and microRNA¹⁰ may also play a role in evaluating stability.

Lesion location also plays a role in determining likely response to vitiligo surgery. Areas with a greater vascular supply and follicular density, such as the face and neck, have better repigmentation rates compared to the extremities.^{11–13} The acrofacial variant of vitiligo, characterized by perioral and/or distal fingertip involvement around the nailbeds, responds poorly to surgery. Areas over joints also respond poorly, likely secondary to increased susceptibility to repeated friction and injury.¹² Patients with a strong tendency toward keloid formation, significant bleeding diatheses, or other relative contraindications to surgery should probably not undergo vitiligo surgery.

CONSULTATION

Preoperative discussion should focus on educating the patient about the procedure, ensuring that the patient is an appropriate candidate, and obtaining informed consent. Peri- and postoperative treatment expectations should be addressed, and complimented by general information about vitiligo and the natural history of this disease. A detailed history and physical examination, including a review of past medical history, current medications, and drug allergies, is necessary to ensure that the patient can safely undergo surgery. Procedural risks, including infection, bleeding, scarring, and pain, should be discussed. It is also crucial that appropriate expectations be set; the lengthy process of repigmentation and color matching should be emphasized, which may take several months to years. Patients should also be aware that they may require adjuvant therapy, including additional surgeries, to maximize treatment response. Providers must also be clear that surgery is a *treatment* and not a *cure* for vitiligo, even in patients with stable disease, as reactivation is always possible.

Preoperative workup

Prior to vitiligo surgery, patients should be screened for blood-borne diseases such as human immunodeficiency virus (HIV), Hepatitis B, and Hepatitis C. This is especially important if dermabrasion will be used in recipient site (RS) preparation, as particles may aerosolize. Most vitiligo surgeries utilize topical or local anesthesia. However, those who elect to undergo general anesthesia should be assessed for preoperative fitness. To establish a baseline and track progress, photos are taken under appropriate lighting both pre- and postoperatively. A Wood's lamp is often used in patients with lighter skin tones to assist in visualizing depigmented areas. Measurements of the donor site (DS) and RS are also recorded ([Table 52-1](#)).

Table 52-1. Screening for Candidacy¹³

Vitiligo History	Vitiligo Type	Lesion Distribution
Favorable	■ Stable disease (6 months–2 years)	■ Focal, segmental types
		■ Face and neck > trunk > extremities
		■ Areas with large vascular supply and greater follicular density
Unfavorable	■ Unstable, progressive disease	■ Nonsegmental types
	■ Koebnerization	■ Acrofacial variant
	■ Hypertrophic scars or keloidal tendencies	■ Perioral
	■ Poor wound healing	■ Distal fingertip
		■ Isolated scalp leukotrichia
		■ Joints
		■ Bony prominences

GENERAL SURGICAL CONSIDERATIONS

Following preoperative evaluation, an appropriate surgical technique is selected; selection is based on the type of vitiligo, lesion location, lesion size, and resource availability.

Site preparation

The DS is an area of normally pigmented skin harvested for transplant to the RS. Typically, it is selected from a cosmetically unimportant area such as the upper or lateral thigh, lower back, lower abdomen, or gluteal area. The depigmented lesions being treated comprise the RS.

After the DS and RS are selected, each must be depilated, cleaned, and anesthetized. Hair is removed by either depilating creams, shaving, or plucking; this reduces interference of hairs with grafting.¹² Alcohol, chlorhexidine, or povidone iodine is typically used to cleanse the donor and recipient sites and can be used in combination. Due to its flammable nature, the use of solutions with a significant alcohol content is not recommended when lasers are used for RS preparation.

For pain control, topical, local, or general anesthesia may be utilized. For small surfaces in less sensitive areas, topical anesthesia may be appropriate. For larger or more sensitive areas, local anesthesia should be administered using a field block with 1% to 2% lidocaine. Infiltration of the anesthetic within the DS is generally minimized to reduce the risk of disrupting the evenness of the skin surface. When dermabrasion is used to prepare the RS, epinephrine is avoided to allow visualization of pinpoint bleeding at the level of the dermal–epidermal junction (DEJ). When treating extensive areas, young patients, and those with high levels of anxiety, general anesthesia may be preferred.

Donor site preparation

Various techniques are employed to harvest tissue from the DS for cellular and tissue grafting. The main methods involve thin to ultra-thin skin grafts, suction blisters, and punch biopsies. Using a shaving technique, thin (0.125–0.250 mm)¹⁴ to ultra-thin (less than 0.125 mm)¹⁵ skin grafts can be harvested using either a sterile razor blade held by hemostats, a Weck blade, a Silver's grafting knife, or a motorized dermatome.^{13,14,16} Maximal operator control of graft size and thickness is obtained with a sterile razor blade, but this method requires a significant degree of skill. The Weck blade allows for uniform graft thickness, but does not allow for adjustment of graft depth. In contrast, the Silver's grafting knife allows for adjustment of depth. Motorized dermatomes provide uniform grafts and require very little user skill, but are more expensive.¹⁷ Appropriate grafts are transparent and float when placed in sterile saline.¹⁸ Curling of the graft edges indicates that the specimen is thick. This can be solved by either reharvesting the graft or by using higher concentrations of trypsin and longer incubation times if cell separation is being performed.

Punch biopsies, typically used for minigrafting or test spots, can also be used to harvest tissue. Equal-sized punch biopsies, usually 1 to 1.5 mm in diameter, are used to take tissue from the DS. Suction blisters are another method of obtaining tissue from the DS. This involves using a Luer lock disposable syringe with a three-way stopcock and pulling the plunger to create a pressure between 30 and 40 mmHg over a period ranging from 15 minutes to 3 hours (Fig. 52-1). This creates a blister, with separation of the skin at the DEJ (Fig. 52-2). Youthful skin requires higher suctioning pressures, whereas more mature skin requires lower suctioning pressures secondary to increased fragility due to decreased elastic fibers in the dermis.¹⁹ Sterile scissors are used to remove the blister, which is either transferred directly or manipulated and then transferred to the RS.¹¹ The speed of blister formation can be accelerated by injection of sterile normal saline (NS) or using heat.¹⁹ This method is not associated with scarring, as separation occurs at the DEJ. However, if excessive suction is employed, hemorrhagic blisters may develop, which may be too thick for use.



Figure 52-1. Suction blister apparatus using a Luer lock disposable syringe with a three-way stopcock and pulling plunger.

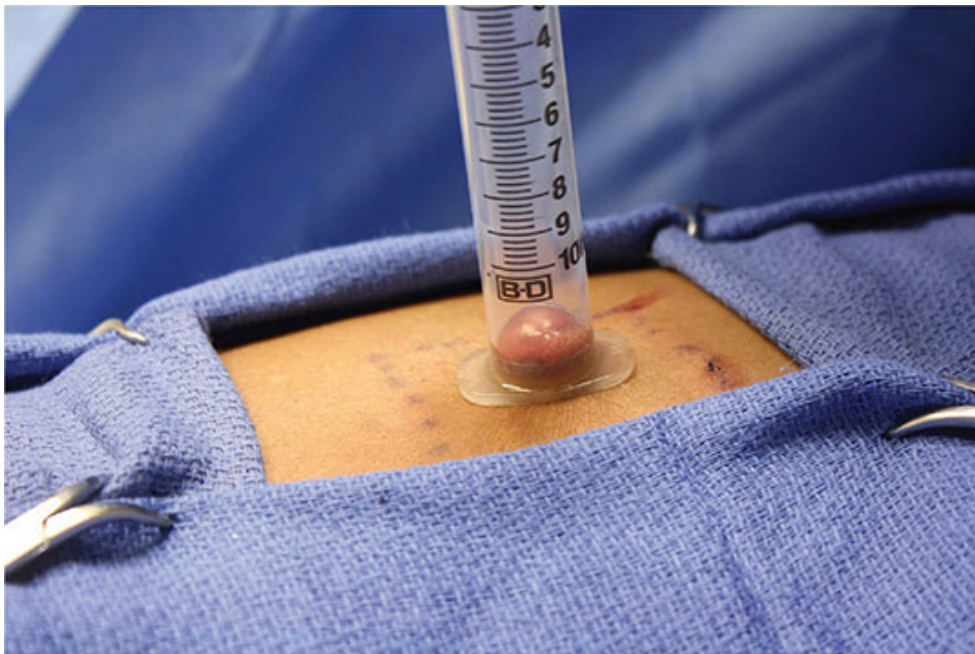


Figure 52-2. Suction blister induction.

Recipient site preparation

The goal of RS preparation is to remove the epidermis, creating a bed suitable for melanocyte transplantation, and to promote graft adherence and nutrition with no to minimal scarring.

Various modalities are available for RS preparation. Cryoblisters formation using liquid nitrogen and chemical preparations such as psoralen with ultraviolet A (PUVA), phenol, and trichloroacetic acid (TCA) can also be used to achieve removal of the epidermis. To prepare the RS using PUVA, 0.075% 8-methoxypsoralen is applied to the RS followed by exposure to 10 J/cm² of long wave ultraviolet A (UVA) for 2 consecutive days prior to surgery. After 24 hours, a blister is formed that can be removed by rubbing with saline-soaked gauze and a wire brush if necessary. This allows for rapid preparation of the RS without scarring, since the reticular dermis is spared, though excessive exposure to UVA has been associated with carcinogenesis.²⁰ Eighty-eight percent phenol or 100% TCA can be used to coagulate epidermal proteins, which are subsequently rubbed off, exposing the RS. Depth control is, however, more difficult using this method.

When using dermabrasion, visualization of pinpoint bleeding is the clinical endpoint. Motorized dermabrasion is quicker and less labor intensive than manual dermabrasion, but still requires user skill to avoid dermal penetration and subsequent scarring. Dermabrasion is effective, inexpensive, and can be used to prepare large areas, but operator fatigue may affect the consistency of results. Protective equipment is required due to the risk of particle aerosolization.

The fractionated carbon dioxide (FCO₂) and erbium glass lasers can also be used for RS preparation. Advantages include a bloodless field and uniform depth of penetration, with less user fatigue than dermabrasion. However, use of laser is associated with higher cost and increased risk of thermal damage and dyspigmentation.²¹

A preliminary study comparing the use of dermabrasion versus FCO₂ in RS preparation found that dermabrasion had slightly better rates of repigmentation than FCO₂, with similar rates of color match.

Hyperpigmentation was noted more frequently with FCO₂, whereas peripheral hypopigmentation was noted with dermabrasion. One patient who underwent dermabrasion developed hypertrophic scarring and atrophy, although this was minimally visible after 9 months. As such, FCO₂ laser may

be of greater benefit when treating large or irregularly contoured areas. In addition, extreme caution should be exercised when using dermabrasion on the eyelid, as eyelashes can be caught in the motorized wheel which may result in eyelid lacerations.²²

Dressings

The goal of dressing placement is to promote graft adherence and melanocyte survival. Dressings stimulate rapid wound healing while decreasing the risk of wound contamination, infection, dyspigmentation, and scarring. Other benefits include reduction of overhydration of the wound, which can cause tissue maceration. Antibacterial ointments should probably be avoided due to the risk of contact dermatitis.

In the first 48 to 72 hours after surgery, graft nutrition is obtained by imbibition, involving the passive absorption of serous drainage from the wound bed. The balance of maintaining graft moisture without causing overhydration is key during this stage. Following closely is inosculation, which occurs when vessels from the graft form connections with those of the wound bed. New vessel growth into the vascularized graft, or angiogenesis, occurs approximately 5 days postoperatively. Dressings provide direct protection during this critical time and should be maintained for at least 72 hours to avoid melanocyte damage during removal. It is better to delay dressing removal to allow for completion of inosculation and optimization of graft uptake. Patients are encouraged to keep the dressing dry to prevent loss of nonadherent melanocytes. Following reepithelialization and initial dressing removal, gauze and nonocclusive dressings can be applied to prevent trauma to the graft.²³

Multiple types and layers of dressing may be placed over transplanted grafts. The initial layer in contact with the graft should be a low-absorbency dressing, which serves to promote graft adherence and prevent wound dehydration. Collagen matrix and paraffin gauze are examples of low-absorbency dressings which can be applied. Collagen dressings are typically used as a base layer for cellular grafts to prevent the suspension from detaching from the RS. They also provide a barrier that is impermeable to bacteria, promotes fibroblast production and cellular migration, and inhibits excessive matrix metalloproteinase production.^{2,24} Paraffin gauze promotes a

moist environment while allowing the passage of drainage through its pores, and can be used as a base layer, or placed over collagen.²⁵ A study comparing collagen-vaseline dressings versus vaseline alone following the melanocyte-keratinocyte transplantation procedure (MKTP) revealed equivalent repigmentation and color matching, although vaseline-only dressings were associated with mild bleeding, as well as increased complexity and patient discomfort with dressing removal.²¹

Adhesive films and membranes, such as Tegaderm, are composed of adhesive sheets that are impermeable to liquids. These can be used to reinforce dressings, but should not generally be used alone in areas with heavy drainage.

Hydrocolloids are moderate-absorbency dressings that can be applied directly to a wound and left in place for several days. Duoderm, a type of hydrocolloid dressing, contains an occlusive polyurethane, which inhibits bacterial contamination. Higher-absorbency dressings, such as cotton gauze, are generally used as secondary dressings to capture excess drainage.²⁵ Cotton gauze tails can be placed between primary and secondary dressings to soak up drainage and prevent dressing detachment, especially in highly exudative areas, such as the head and neck region (Fig. 52-3). Micropore tape, Cover-roll, or Tegaderm can be used to further secure all of the dressings.



Figure 52-3. Tails made from cotton sponge can be added to head and neck dressings to wick away excess moisture.

SURGICAL TECHNIQUE

Surgical techniques in vitiligo are broadly classified as either tissue or cellular grafts.

Tissue grafting techniques

Tissue grafting involves the transfer of intact tissue from a DS to a depigmented RS. Tissue grafting options presently available include split-thickness skin grafting (thin or ultra-thin types) (STSG), smash grafting (SG), suction blister epidermal grafting (SBEG), punch grafting (PG), minipunch grafting (MPG), flip-top grafting (FTG), follicular unit transplant (FUT), and follicular unit extraction (FUE).

Split-thickness skin grafting

First performed for the treatment of vitiligo by Haxthausen in 1947, STSG is considered one of the most effective methods of inducing repigmentation.²⁶ This technique was refined further in 1964 by Behl, who was the first to describe the use of thin Thiersch grafts.²⁷ Later in 1996, Kahn and Cohen utilized a motorized dermatome to obtain ultra-thin STSGs for vitiligo surgery.¹⁴

Using this approach, a thin to ultra-thin STSG is harvested from the DS and temporarily placed in a sterile Petri dish filled with NS while DS dressings are placed and the RS is prepared by either laser or dermabrasion. The graft is then removed from the NS, placed dermal side down over the RS, and covered with appropriate dressings.²⁶ A slide may be placed underneath the graft while it is being cut to more easily differentiate between the epidermal and dermal sides (Fig. 52-4). Alternatively, a marking pen may be used. The dermal side can also be distinguished by visualization of fibrin clots as well as inward curling. On digital microscopy, creasing is seen on the epidermal side.



Figure 52-4. Placement of an STSG on the distal fingertip in a research patient using a glass slide.

The STSG technique is a desirable option when treating large areas, challenging areas such as the eyelids, areola, and genitals, and leukotrichia. This method is effective, and pigment return is fast and uniform. STSG is an in-office procedure, not requiring reagents, a lab, or expensive equipment. Drawbacks include hyperpigmentation, especially peripheral halo pigmentation, although this can be minimized by obtaining a DS graft 10% to 20% larger than the RS site to account for graft contracture during healing. Milia and inclusion cysts may occur 2 to 4 months following the procedure,²⁶ as well as peripheral beading, the inward curling of the graft rim during healing. Composite film and graft units, consisting of a semipermeable film extending past the graft edges, may be utilized to reduce the risk peripheral beading.²⁸ In addition to graft hypertrophy, pincushioning, manifesting as a tire patch or stuck on appearance, can be seen when thicker grafts are placed. Graft rejection and DS scarring may also occur.²⁶

Mesh grafting

Mesh grafting is a modification of STSG that can be implemented to amplify graft size. Small slits are made throughout the graft to achieve a mesh-like appearance, thereby increasing graft size while also providing a route for

exudative drainage at the RS.²⁶ DS scarring may occur, and peripheral beading can be seen with thicker grafts.²⁶

Smash grafting

Using this approach, a thin to ultra-thin graft is smashed into small pieces using sterile scissors for about 15 to 20 minutes until a smooth paste is created. The paste is then placed in NS to maintain graft moisture. Once the RS is prepared, the excess NS is drained and a sterilized spatula is used to apply the paste. The paste remains exposed to room air for 15 to 30 minutes to optimize graft adherence and allow for mild drying. Patients are placed on prophylactic antibiotics until dressings are removed 1 week later.²⁹

Smash grafting has the distinct advantage of requiring equal amounts of DS and RS tissue compared to the greater DS graft size required in STSG to account for RS contracture. This method also eliminates the need for marking the dermal side to ensure proper graft placement at the RS, as is required for STSG and SBEG. It generally takes at least 2 weeks postoperatively to see pigment spread, at which time phototherapy can be initiated. Repigmentation is typically expected by 6 months postoperatively. Studies have shown excellent color and texture match, and this technique is simple, requires minimal specialized equipment, and is cost-effective.²⁹

Suction blister epidermal grafting

SBEG was first developed by Falabella in 1971. In this procedure, a suction blister is raised, harvested, and transferred to the prepared RS with the dermal side down using flat forceps. The graft is then covered with dressings which are subsequently removed 7 days later.¹¹

SBEG is useful for cosmetically sensitive areas such as the eyelids. Hyperpigmentation is more commonly seen in those with darker skin types.¹¹ Other complications such as peripheral halo depigmentation, milia, and hypertrophy can be seen. A study comparing SBEG and STSG in 20 patients with stable, generalized vitiligo found STSG to be superior.³⁰ A comparison between SBEG and noncultured epidermal cell suspension (NCES) was also performed, and showed faster repigmentation with the SBEG group but

greater overall repigmentation in the NCES group. SBEG does not have the same learning curve or expense as epidermal suspension options.³¹

Minigrafting and punch grafting

PG was first described by Falabella for use in vitiligo in 1978, when 1- to 2-mm punch grafts were associated with perigraft pigment spread of approximately 3 mm. In 1983, Falabella observed that a graft size of 1 mm could lead to repigmentation of a vitiliginous area 25 times that size.³² Although cobblestoning was commonly reported initially, it was observed that this textural abnormality could be avoided if smaller punches were taken, leading to the advent of MPG. The standing recommendation is that punches should not exceed 1.5 mm and in areas involving the face and lips, the preference is between 1- and 1.2-mm punches.⁴

Using this method, grafts are transferred from the DS into RS chambers using either a syringe needle or the tip of scissors and placed in close proximity to the border of the depigmented lesion. This reduces the risk of perigraft halo. RS punches are spaced approximately 5 to 10 mm apart from each other, with slightly larger DS punches used to account for graft contracture. Dressings are removed after approximately 7 days. Complete repigmentation is typically observed by 3 to 6 months.³²

Complications such as cobblestoning, color mismatch, hypertrophic scarring, keloid formation, and graft rejection can occur at the RS. DS complications may include depigmentation and scarring. Of all of the available vitiligo surgery techniques, PG and MPG are considered the easiest, fastest, and least costly. With the exception of the angle of the mouth, the treatment can be used anywhere.³²

A study comparing MPG with STSG in 64 patients with stable focal, segmental, acrofacial, and vulgaris vitiligo subtypes found that patients who underwent STSG had greater repigmentation, better color matching over larger areas using fewer grafts, and less graft failure.³³ Another study involving 50 patients with stable focal, segmental, and generalized vitiligo types compared PG with SBEG and found that SBEG showed faster repigmentation and better cosmesis.³⁴ Perigraft halo at the RS is seen more commonly with PG than SBEG.¹¹

Flip-top grafts

Developed by McGovern, Bologna, and Leffell in 1999, FTG is a technique that involves placing small grafts at the RS, which has a hinged flap of epidermis that serves as a biologic dressing.³⁵ Using this method, a DS is selected from a normally pigmented area in either the upper medial arm or axilla. A 30-gauge needle attached to a syringe filled with 1% lidocaine with epinephrine is used to inject into the upper portion of the dermis, creating a small wheal. A 2- to 4-mm strip of raised epidermis with some dermis is obtained manually using a sterile razor blade. The graft is then placed on gauze, soaked in isotonic sodium chloride solution, and divided into 1- to 2-mm wide grafts. Similarly, a wheal is raised at the RS using 1% lidocaine with epinephrine and a sterile razor blade is used to elevate a flap of epidermis with minimal papillary dermis. A portion of the RS flap is left connected to the dermis, while the disconnected portion is flipped over, exposing the dermal side. The graft is then transferred to the RS with the dermal side down and the epidermal flap (with the epidermal portion of the graft in contact with the dermis of the hinged flap) is folded back over atop of the graft. Cyanoacrylate is used to tether the graft edges to the RS and dressings are applied. Graft survival is assessed after 1 week by the presence of pigmented macules under the flap, and repigmentation is assessed after 1 month.^{26,35}

The FTG technique is notable for demonstrating pigment spread beyond the graft. Little scarring is observed and the lack of cobblestoning can be attributed to graft placement below the epidermis. Advantages of FTG include simplicity, lack of specialized equipment required, and low cost.³⁵ A study compared FTG and MPG in 20 patients with stable focal, segmental, and generalized vitiligo types and found that both were equally effective in treating vitiligo. However, FTG was associated with higher graft uptake rate and pigment spread.³⁶

Follicular unit transplant

First introduced in 1998, FUT capitalizes on the use of undifferentiated stem cells associated with hair follicles to replenish melanocytes in areas of leukotrichia. A melanocyte reservoir consisting of inactive melanocytes

(Dopa-negative) exists in the outer root sheath (ORS) of hair follicles.³⁷ In vitiligo, the active melanocytes (Dopa-positive) in the dermis are destroyed, whereas inactive melanocytes are unaffected.³⁸ If induced by ultraviolet light therapy or by removal of the associated epidermis, the inactive melanocytes can convert to active melanocytes, as described by Starrico in 1959.³⁹ Once activated, these melanocytes can migrate toward the epidermis and induce perifollicular pigmentation, while the hair matrix migrates downward to make melanin, as outlined by Cui et al. in 1991.^{37,38}

In follicular grafting, the donor graft is typically selected from the occipital or posterior-auricular aspect of the scalp. Here, the donor graft is obtained by using the strip method (known as the FUT method), where a strip of follicles is harvested from the scalp and then dissected into follicular units.³⁸ The extracted hair follicles are then placed in a Petri dish filled with cold NS. Meanwhile, the RS is prepared by making slits using either a hair transplantation machine, a curved cutting needle, or an 18-gauge needle, to allow for insertion of the hair follicle graft via jeweler's forceps. After 10 days, adjuvant therapy can be initiated.³⁸

This technique is advantageous for hair-bearing areas, as leukotrichia can be reversed. A greater number of melanocytes are found in a single hair follicle, which corresponds to a larger melanocyte and stem cell reservoir compared to normal nonglabrous skin. This procedure is useful for smaller, more difficult to treat areas such as the eyelashes. Benefits include excellent color matching and a lack of textural abnormalities such as cobblestoning. Additionally, this is a low cost procedure that does not require specialized equipment or a laboratory.⁴⁰ There is, however, a longer time required to see repigmentation compared to FUE. FUT is generally not appropriate for non-hair-bearing regions.

Follicular unit extraction

FUE, also known as the follicular isolation technique, relies on punch biopsies for follicular extraction. Typically, 1-mm wide punches are used to remove single follicular units. This technique avoids disturbing the original hair follicle environment, which likely aids in growth and graft uptake. The RS can be prepared by creating 1-mm punches, spaced approximately 3 to 10 mm apart, with follicular units being placed into the chambers.³⁸

In comparison to FUT, FUE is considered an easier technique, and is preferred in those with limited donor area size and smaller treatment areas. However, operator skill is also required to prevent follicular unit dissection, and fewer follicular grafts can be harvested in a single session due to the nature of the procedure. FUE grafts are often used to spot-treat achromic areas not repigmented using FUT.⁴⁰ Two recent studies found FUE to be successful in treating eyelash leukotrichia.^{41,42} When compared to FUT, FUE treatment areas heal faster, and the DS does not scar or require dressing.³⁸ One study compared FUE and PG in 25 patients with stable, nonsegmental vitiligo and found that there was no statistically significant difference in efficacy; however, in terms of ease of execution, PG is considered a better option.⁴³

Cellular grafting techniques

Cellular grafting involves transferring melanocytes from the DS to the RS as a suspension with or without the use of cell culture. Cellular grafting techniques presently available include noncultured epidermal suspensions (NCES), cultured melanocyte suspensions (CMS), cultured epidermal suspensions (CES), and noncultured hair follicle outer root sheath cell suspensions (NCORSHFS).

Noncultured epidermal cell suspensions

The NCES technique for the treatment of vitiligo was first developed by Gauthier and Surleve-Bazeille,⁴⁴ refined by Olsson and Juhlin,^{45,46} and further modified by Mulekar.⁴⁷ The NCES technique has the distinct advantage of utilizing a DS to RS ratio of approximately 1:10, allowing for the treatment of larger areas.

Using this method, an ultra-thin skin graft is harvested from the DS, rinsed with NS, and immersed in a Petri dish containing trypsin. The trypsin must be removed from the refrigerator, brought to room temperature, and incubated at 37°C for 45 minutes before the graft is incubated. The sample is then incubated at 37°C with the epidermis facing upward for approximately 20 to 30 minutes, depending on graft thickness. After the graft is removed from the incubator, the trypsin is discarded and the graft rinsed with lactated Ringers

(LR) six times. Next, the epidermis is manually separated from the dermis using forceps. The epidermis is subsequently broken down into small pieces using forceps, and the dermis is discarded. The epidermal fragments are rinsed with LR and transferred to a tube for centrifugation for 5 minutes at 2,000 rpm. However, this is dependent on the make and model of the centrifuge used. Once the cell pellet containing melanocytes and keratinocytes forms, any large tissue fragments are removed, and the pellet is resuspended in LR and transferred to a 1-mL syringe. The suspension should have a cloudy appearance, and may appear pigmented depending on the patient's skin type (Fig. 52-5).



Figure 52-5. Cell suspension for noncultured epidermal cell suspension graft. Note cloudy appearance, which can have a brownish color in more pigmented individuals.

Once the RS is denuded to the level of the DEJ using either dermabrasion or laser, the cellular suspension may be applied to the RS through the hub of the syringe. Dressings are removed 4 to 7 days later, depending on RS location (4 days for the head, neck, and genitals and 7 days for the trunk and extremities).¹⁶ Repigmentation is usually observed between 2 weeks and 2 months postoperatively, with maximum repigmentation gained by 6 to 18 months. Color match typically improves with time¹³ (Fig. 52-6).

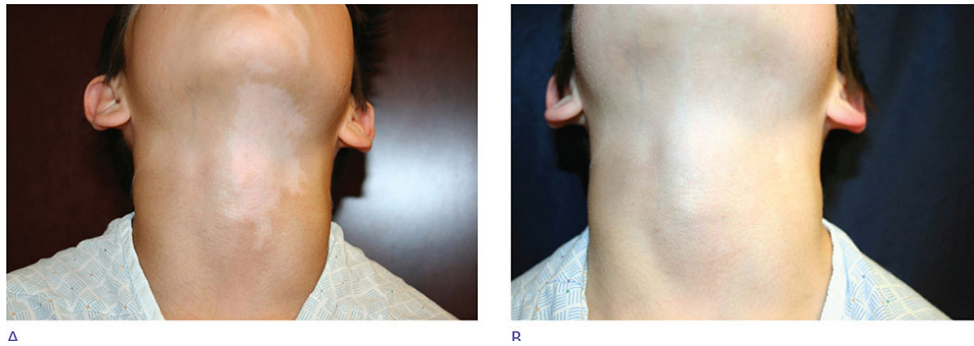


Figure 52-6. (A) Anterior neck at baseline. (B) Anterior neck 7 months after treatment with NCES graft. Greater than 95% repigmentation achieved with excellent color match.

A study comparing NCES with SBEG in 41 patients with stable focal, segmental, and generalized vitiligo types found that more NCES-treated lesions had excellent repigmentation, but both groups showed excellent color match. Repigmentation was observed slightly earlier in the SBEG group, which may be attributed to the higher melanocyte density in SBEG.³¹ However, the overall lesser repigmentation in SBEG may be due to a reduced number of viable melanocytes in the epidermis secondary to longer suctioning times, as reported by Czajkowski et al.⁴⁸ A greater degree of repigmentation in NCES may also be attributed to the maintenance of keratinocytes during NCES grafting, since they greatly contribute to the growth and development of melanocytes at the RS. In contrast, keratinocytes are lost with the shedding of the epidermal graft 1 to 2 weeks following SBEG after melanocytes release to the RS.³¹

Cultured melanocyte suspensions

The CMS technique was first performed by Olsson and Juhlin in 1993 for the treatment of vitiligo.⁴⁹ Similar to NCES, an ultra-thin skin graft is harvested and trypsinized; the suspension is then combined with culture medium, in addition to Dulbecco's Modified Eagle Medium (DMEM), followed by incubation at 37°C for approximately 3 weeks. During this time, culture fluid is replaced daily. Part of the cultured cell suspension is then removed and stained with Trypan blue, which aids in determining viable melanocyte density, with a goal of 1,000 to 2,000 melanocytes/mm² needed for successful transplantation. Once achieved, the cells are detached from plates

and applied as a suspension to the prepared RS. The site is then covered with gauze presoaked in culture medium, followed by dressing placement. Bed rest is recommended for 1 to 10 hours, and dressing is typically removed after 7 to 10 days.⁵⁰

Melanocyte expansion from a small DS using cell culturing makes CMS a useful method to treat large areas. One study showed no difference in repigmentation rate when a high (1:10–1:160) versus a low ratio ($\leq$ 1:10) was used for CMS.⁵⁰ However, multiple sessions are required along with as a well-equipped laboratory with skilled technicians to isolate, culture, and cultivate melanocytes, making this a costly procedure.⁵⁰

A review of the literature suggests that CMS and NCES produce similar results, and are both effective methods of inducing repigmentation. A distinct advantage of CMS is the ability to achieve a donor to recipient area ratio of up to 1:100 compared with 1:10 in NCES.⁵¹ However, the longer incubation and cell culture time, as well as the higher cost associated with a laboratory, makes CMS less desirable.⁵¹ There is also a theoretical risk of malignancy associated with the CMS technique, as one of the components of the culture medium, 12-tetradecanoylphorbol 13-acetate (TPA), is a tumor promoter. The advent of TPA-free solutions and mediums has made this less of a concern.⁵² A study involving 25 patients with stable local, segmental, mucosal, acrofacial, and vulgaris vitiligo types compared NCES and CMS and found that a greater number of NCES-treated patches demonstrated greater than 70% repigmentation. However, there was no statistically significant difference in repigmentation between the two groups.⁵¹

Another study compared CMS plus PUVA, SBEG plus PUVA, cryotherapy plus PUVA, and PUVA alone in 20 patients with stable focal and generalized (acrofacial) vitiligo. There was no statistically significant difference between SBEG and CMS in terms of graft survival and time to repigmentation, but there was a complete lack of effectiveness observed in the groups treated with cryotherapy plus PUVA and PUVA alone.⁵³ Another study involving 132 patients with stable piebaldism, halo nevi, and focal, segmental, and vulgaris vitiligo types compared CMS, ultra-thin STSG, and NCES treatment methods, and found that patients treated with STSG had better overall results.⁴⁵

Cultured epidermal suspensions

The CES technique involves the culturing of both melanocytes and keratinocytes. Their dual presence is beneficial in that they can organize in a manner mirroring the basal layer of the skin. Using this method, an ultra-thin skin graft is harvested and trypsinized. The isolated melanocytes and keratinocytes are placed in culture media containing growth factors for both cell types for a few weeks. Dispase can then be used to detach the formed epidermal sheet, which is subsequently placed on top of paraffin gauze and transferred to the prepared RS. When compared to CMS, less culture time is required, though like CMS this is a costly procedure ([Fig. 52-7](#)).^{12,54}

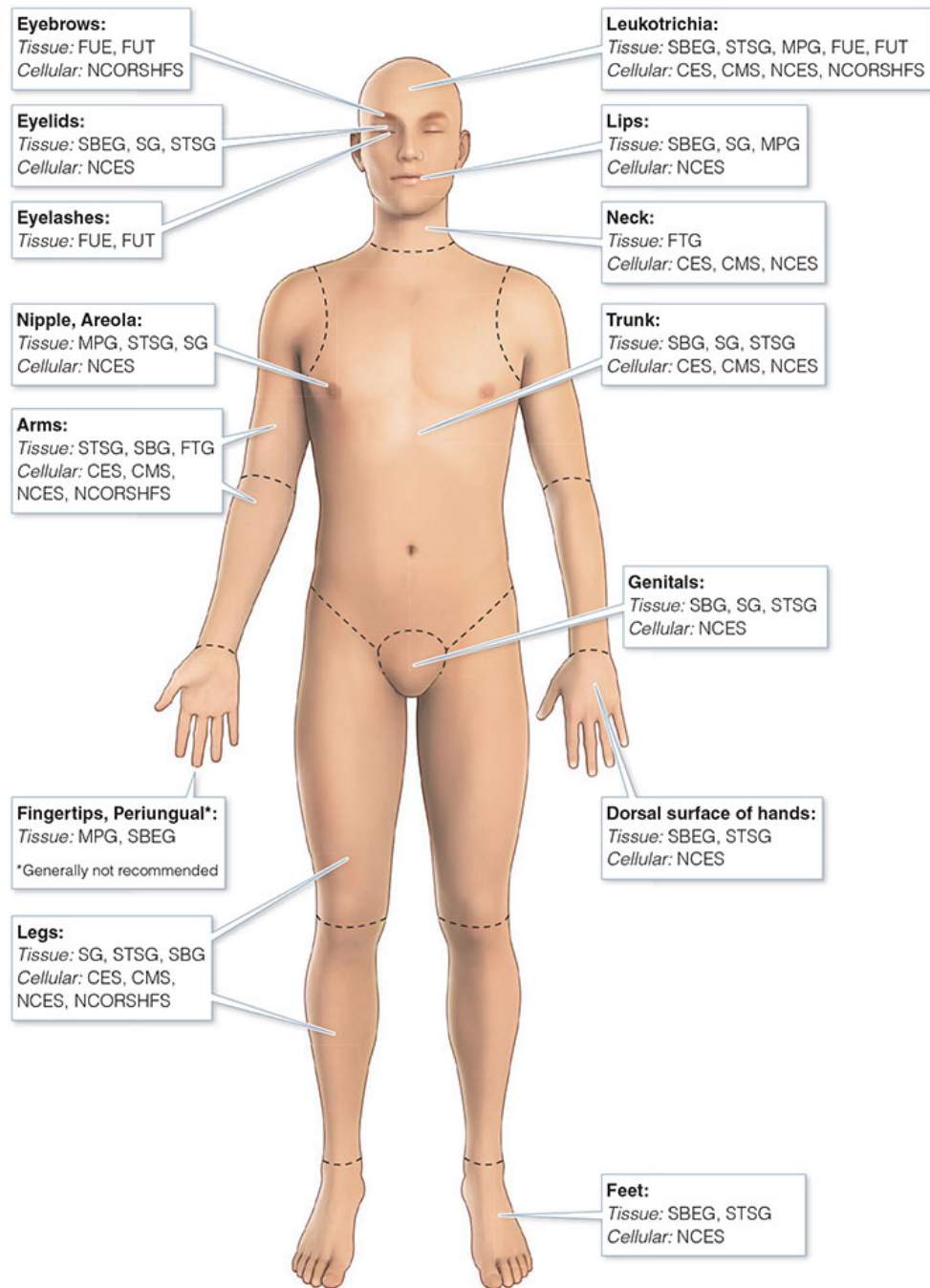


Figure 52-7. Preferred vitiligo surgery techniques by body area.

Hair follicle outer root sheath cell suspensions

A case series by Vanscheidt et al. in 2009 first introduced the use of a cell suspension derived from plucked hair follicles for vitiligo grafting.⁵⁵ In this

technique, follicles are harvested by plucking or by the FUE method, the latter of which was done as a modification to the procedure by Kumar et al.⁵⁶ The hair follicle is then placed in a transport media and decontaminated using antibiotic washing. Trypsin is added to separate the cells of the ORS. The cells are then incubated at 37°C for 90 minutes. For every 30 minutes of incubation, the sample is transferred to a new tube of trypsin-ethylenediaminetetraacetic acid (EDTA), and trypsin inhibitor is added to the previous tube to neutralize the proteolytic activity of trypsin. Following incubation of the third tube, the hair shaft is discarded and the supernatants from all three tubes are combined and passed through a cell strainer to separate out any remaining fragments of the hair shaft, followed by microscopic examination to confirm cell viability. The solution is then centrifuged at 1,000 rpm for 5 minutes to create the cell pellet, which is resuspended and applied to the prepared RS and dressed. The attraction of this procedure is its simplicity, minimal invasiveness, immediate results, and repeatability, though a notable drawback is the low cell yield.⁵⁶

A study comparing lesions treated with NCES versus NCORSHFS in 30 patients with stable focal, segmental, and generalized vitiligo types found both to be safe, effective, and simple techniques to establish repigmentation. Both groups demonstrated excellent repigmentation. However, more NCES lesions showed good repigmentation when compared to the NCORSHFS group, a difference that was statistically significant. Both groups showed excellent color match and significantly reduced Dermatology Life Quality Index (DLQI) scores, although the difference was not statistically significant (Tables 52-2 and 52-3).⁵⁷

Table 52-2. Summary of Outcomes Observed in Clinical Studies Comparing Vitiligo Surgery Techniques^{30,31,33,34,36,43,45,51,53,57,58}

Techniques	Repigmentation	Color Matching	Graft Failure	DLQI Score
Tissue Grafting	■ Thin STSG > SBEG, MPG ■ PG > FTG ■ FUE > MPG ■ PG = SBEG ■ MPG = SBEG	■ Thin STSG > MPG ■ MPG > SBEG	■ SBEG > Thin STSG ■ MPG > Thin STSG ■ PG > SBEG ■ PG > FTG ■ MPG = FUE	–
Cellular Grafting	■ NCES = CMS, NCORSHFS	■ NCES = NCORSHFS	–	■ NCES = NCORSHFS
Tissue versus Cellular Grafting	■ NCES > SBEG ■ Ultra-thin STSG > NCES, CMS ■ CMS = SBEG	■ NCES = SBEG	–	■ NCES > SBEG

Table 52-3. Summary of Adverse Events Observed in Clinical Studies Comparing Vitiligo Surgery Techniques^{30,31,33,34,36,43,45,51,53,57,58}

Techniques	Adverse Effects at Donor Site	Adverse Effects at Recipient Site
Tissue Grafting	Thin STSG ■ Koebner phenomenon ■ Hypopigmentation ■ Infection ■ Superficial scarring ■ Hypertrophic scarring	Thin STSG ■ Pigment regression ■ Pigmented papules ■ Achromic fissuring ■ Graft contracture ■ Milia ■ Tire-pattern appearance ■ Scarring
	SBEG ■ Koebner phenomenon ■ Hyper/hypopigmentation ■ Superficial scarring ■ Infection	Ultra-thin STSG ■ Hyperpigmentation ■ Peripheral hypopigmentation
	MPG ■ Superficial scarring	SBEG ■ Pigment regression ■ Pigmented papules ■ Peripheral hypopigmentation ■ Variegated appearance ■ Infection ■ Hyper/hypopigmentation
	PG ■ Superficial scarring ■ Infection	MPG ■ Variegated appearance ■ Depigmentation ■ Cobblestoning
Cellular Grafting		PG ■ Variegated appearance ■ Hyperpigmentation ■ Cobblestoning
		FTG ■ Variegated appearance ■ Cobblestoning ■ Hyperpigmentation
	NCES ■ Erythema ■ Infection ■ Pigment regression	NCES ■ Infection ■ Pigment regression ■ Hyper/hypopigmentation
	CMS ■ Infection ■ Pigment regression ■ Hyperpigmentation ■ Peripheral hypopigmentation	CMS ■ Infection ■ Pigment regression
		NCORSHFS ■ Hyper/hypopigmentation

Postoperative care

Following surgery, patients should be provided with specific instructions on how to care for their graft. Patients are encouraged to wear loose clothing to the procedure to avoid any postoperative displacement or damage to the dressing. It is recommended that patients keep the dressings dry and limit movement at the RS until the dressing removal is performed to ensure graft survival. Elevation of the RS is encouraged to avoid edema and discomfort. For control of postoperative pain, over-the-counter nonsteroidal anti-inflammatory agent or acetaminophen is generally sufficient. Patients may notice a green exudate on the dressings; they should be counseled that this results from neutrophilic release of myeloperoxidase rather than infection (Fig. 52-8).²³ Concerning signs and symptoms include fever, chills,

expanding erythema, warmth, foul odor, and excessive pain. If infection is suspected, antibiotics are indicated.

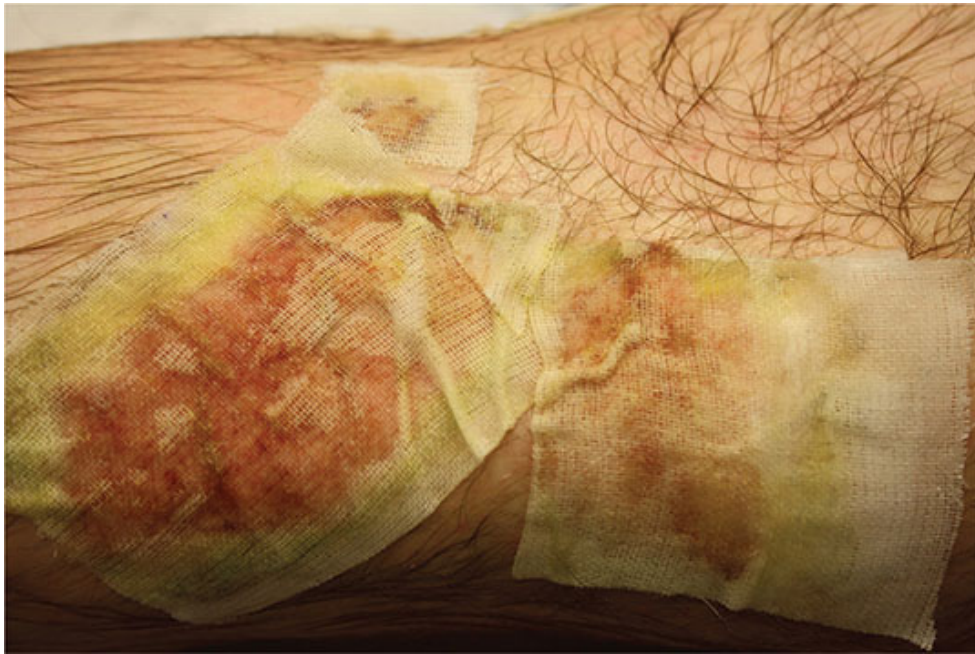


Figure 52-8. Greenish exudate on dressings postoperatively are expected and not an indicator of infection.

When the patient returns for dressing removal, all materials should be removed gently to avoid trauma to the graft. Saline can be used to facilitate dressing removal in adherent areas with crusting. The collagen dressing layer is left intact, as it is either absorbed into the skin or detaches once the epidermis is healed. Edges that become loose should be trimmed to avoid being caught on clothing and peeling off prematurely. Following dressing removal, patients are instructed to wash the treated site with a mild cleanser and avoid vigorous rubbing at the site. Vaseline should be applied to the DS and RS to promote healing until the areas do not burn when dry. Patients should not use any other products on the treatment site including cosmetics, medications, or lotions for at least 1 week postoperatively. Shaving can be resumed one week following bandage removal and should be performed in the direction of hair growth for at least 45 days after surgery; thereafter, the hair may be shaved against the grain if desired. Swimming should be avoided for 1 month after treatment due to the presence of potentially harsh chemicals in the water.

POSTOPERATIVE EVALUATION

Multiple modalities are available to evaluate repigmentation in patients who have undergone vitiligo surgery. Visual evaluation, tracings, and photography with or without adjunct software analysis can be used. Validated scoring systems which can be used include the VASI, VETF, and Vitiligo Scoring Tool, which is a more comprehensive approach that evaluates repigmentation, color match, and postsurgical complications.⁵⁹ Patterns of repigmentation are categorized as follicular, marginal, diffuse, or combined, while color match is graded as excellent, good, fair, or poor, and takes into consideration any pigmentary variations. Adverse effects related to the DS and RS are noted, including change in pigment or texture, scarring, keloids, cobblestoning, milia, or infection.¹² Given the psychosocial impact of vitiligo, quality of life is measured before and after treatment using validated measures, such as the Dermatology Life Quality Index (DLQI), Skindex, and Vitiligo Specific Quality of Life Instrument (VitiQoL). Such measures help reinforce the efficacy of surgery not only in inducing repigmentation, but also in relieving psychological distress and improving patient productivity and quality of life. As vitiligo surgery is currently not covered by insurance in the United States, this is instrumental in influencing insurance companies that such procedures should be covered.

Postoperative considerations and adjuvant treatments

A variety of adjuvant therapies exist which can be used postoperatively to optimize repigmentation. Topical agents such as calcineurin inhibitors reduce immune response while avoiding the atrophy that may occur with excessive topical corticosteroid use.

Oral adjunctive therapies include antioxidants such as ginkgo biloba and alpha lipoic acid that may be possibly used to induce disease stability, since active disease is associated with impaired clearance of reactive oxygen species within affected melanocytes.⁶⁰ Oral minipulse steroid (OMP) therapy can be used to promote repigmentation and induce disease stability. A study by Mulekar used betamethasone OMP therapy, given at a dose of 0.1 mg/kg body weight per week, in patients with vitiligo vulgaris and segmental

vitiligo who failed to show repigmentation between 2 and 11 months following MKTP. The results showed that the majority of patients had excellent repigmentation following subsequent transplantation sessions. OMP can be associated with some side effects, such as weight gain and acne. More serious adverse events are uncommon due to the low dose and short duration of therapy.⁶¹

Postoperative irradiation using narrowband ultraviolet B (NB-UVB) is thought to have a proliferative and stimulatory effect on transplanted melanocytes,¹⁸ while stabilizing disease.⁶² NB-UVB can be associated with mild pruritus and erythema, but is otherwise well tolerated.⁶³ Compared to PUVA, NB-UVB is considered more safe in adults and children with vitiligo.^{18,64,65} Finally, additional surgery may be necessary in areas with suboptimal results.

Micropigmentation (tattooing)

The use of micropigmentation, or tattooing, can be a good option for camouflage in patients with stable and localized vitiligo. Its use was first reported for the treatment of vitiligo by Halder et al. in 1989.⁶⁶ This treatment involves the insertion of pigment into the dermis using either manual needles or electrically powered devices, such as tattoo guns or pencils. These devices typically have multiple stainless steel 25-gauge needles that are spaced about 0.3 mm apart, with adjustable speed and depth of penetration.¹² The ideal depth for pigment placement is in the upper papillary dermis, which is approximately 1 to 2 mm deep depending on location. If the depth is too superficial, extrusion of pigment occurs, and if the pigment is placed too deeply in the dermis, it is cleared by macrophages, leading to an unsatisfactory appearance. Pigment may also migrate to regional lymph nodes, leading to fading of the tattoo.⁶⁷

The main pigments utilized for tattooing include titanium dioxide (white), cinnabar and mercuric sulfate (red), iron oxide (black, camel yellow, light brown, and dark brown), and cadmium sulfide (yellow), which are available as powders.⁶⁸ These are often blended using isopropyl alcohol, NS, water, or glycerin prior to tattooing to achieve the correct consistency and color that matches surrounding skin. The area to be tattooed is then marked and anesthetized using 1% to 2% lidocaine with epinephrine to achieve uniform

penetration. A thick layer of pigment is then applied to the skin, which is stretched prior to needle insertion. An angle of approximately 45 degrees is utilized to improve visualization of pigment deposition after insertion. The area is then dressed with a layer of antibiotic ointment and a pressure dressing. Multiple sessions may be required to achieve proper color match.^{12,67,69}

This procedure has achieved good results in mucosal and gingival areas as well as the nipples, and may be used in areas traditionally more resistant to medical management such as the fingers, wrists, elbows, and ankles. Optimal results are seen in patients with darker skin types.⁶⁸ However, there are many drawbacks associated with this procedure. Risks include reactivation of herpes simplex virus, secondary bacterial infections, ecchymoses, edema, and crusting. Transmission of blood-borne diseases, such as HIV, Hepatitis B, and Hepatitis C can also occur. Risk of infectious disease transmission can be nearly eliminated through the implementation of sterile technique, as well as sonic cleaning and autoclaving of the instruments and tattoo pigments prior to every procedure.⁷⁰ Allergic responses to pigments, including contact dermatitis, photo-aggravated reactions, and granulomatous reactions are also possible.⁷¹

Postprocedurally, issues with color match may arise. Superficial penetration of pigment can lead to a faint appearance of the tattoo, while deeper penetration into the dermis can result in blue discoloration. Migration of pigment to the lymph nodes can also lead to fading of the tattoo. As such, periodic touch-ups may be required to maintain the original color. Another possible complication is oxidation of tattoos containing metal oxides, resulting in a black appearance that is very difficult to remove. Tanning of normal skin in summer months can also lead to contrast between the tattoo and surrounding skin. Finally, micropigmentation can result in koebnerization, creating a cosmetically unacceptable appearance.^{67,71}

Although micropigmentation can be used for camouflage of vitiligo lesions, it is not generally recommended due to color variations over time, the need for re-application, and the possibility of koebnerization. However, if a patient does decide to pursue this option, they should seek treatment with an experienced medical tattooist to avoid adverse events and dissatisfaction.

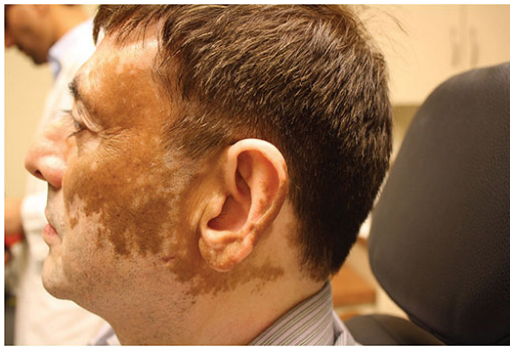
Laser-mediated depigmentation

For patients with extensive and recalcitrant vitiligo, laser-mediated depigmentation is an option to achieve a uniform skin tone. The most commonly reported lasers used for depigmentation include the Q-switched ruby (694 nm), Q-switched alexandrite (755 nm), and Q-switched Nd:YAG lasers (532 nm). As the absorption spectrum of melanin falls between 600 and 800 nm, these lasers function by targeting melanosomes in residual melanocytes by selective photothermolysis and photoacoustic effects.^{72,73} The higher the wavelength of the laser, the deeper its penetration into the skin. Lasers have shown greater efficacy in certain patient populations, specifically those with active disease and a tendency toward koebnerization, as this induces depigmentation.⁷⁴ Laser-mediated depigmentation can be used in combination with monobenzyl ether of hydroquinone, a topical depigmenting agent, for better results.

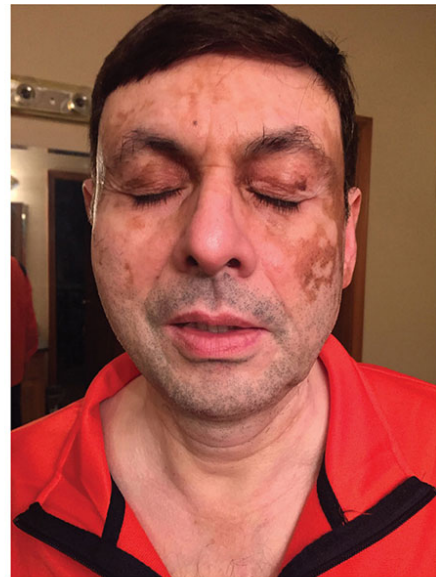
This procedure involves marking the areas to be treated followed by administration of either topical or local anesthesia with lidocaine. Protective goggles must be worn by all personnel in the room, as well as the patient. The clinical endpoint of tissue whitening is used to determine the appropriate fluence setting used during treatment with the laser (Fig. 52-9). A crust will develop that will peel off approximately 1 week after the procedure. Approximately 6 to 8 weeks should pass between sessions to allow adequate time for depigmentation (Fig. 52-10). Adverse events associated with laser-mediated depigmentation include swelling, erythema of the surrounding skin, and pain that is typically described as a bad sunburn. Cold packs, emollients, and mild analgesics can be used to alleviate these symptoms. Patients are counseled to practice strict photoprotection postprocedure to avoid repigmentation.^{48-51,53}



Figure 52-9. Tissue whitening, which is the clinical endpoint for laser-mediated depigmentation.



A



B

Figure 52-10. (A) Left cheek and ear at baseline. (B) Appearance 9 months after a single session of 532 Q-switched Nd:YAG for depigmentation.

CONCLUSIONS

Vitiligo is a disfiguring disorder and treatment is challenging. However, an appropriately selected candidate may benefit from one of the various surgical techniques available. The risks and benefits of each procedure must be weighed, and physicians and patients should be prepared to consider alternative therapies if faced with treatment failure. Future research may focus on optimizing existing approaches in vitiligo surgery and developing new, sophisticated, and effective adjunctive therapies to optimize treatment response.

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CHAPTER 53 Chronic Wounds

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SUMMARY

- Chronic wounds are a common problem, and are a major source of morbidity and expense in the healthcare system.

- While standard care for chronic wounds is predicated on several fundamental principles, such as off-loading and compression, surgical approaches to these wounds are increasingly used to augment healing and increase the chances that a given wound will heal.

Beginner Tips



- There is no clear guideline on the extent to which wounds should be surgically debrided, though debridement should be directed toward removal of nonviable tissue, including overlying eschar, periwound callus and fibrinous slough within the wound bed.
- Multiple debridements are often necessary, as debridement frequency has been associated with greater healing benefit.

Expert Tips



- In skin grafting, donor site selection should be determined by its ability to be concealed, similarity to recipient skin, potential discomfort, and healing capability.

- Prior to skin grafting or application of skin substitutes, proper wound bed preparation, such debridement and treatment of infection, must be achieved to ensure success.
- Flaps should be properly planned and sized to maintain perfusion that may otherwise be restricted due to tension of wound closure.

Don't Forget!



- To control exudate and prevent fluid buildup beneath graft skin and skin substitutes, absorbent dressings should be chosen to prevent graft elevation.
- In most cases, surgical treatment does not correct the underlying pathophysiology of disease; thus patients should continue standard of care treatment, including compression therapy for VLU patients and maintenance of wound bed preparation and offloading for DFU and pressure ulcer patients.

Pitfalls and Cautions



- In patients with skin graft or flap procedures, maturation may take over a month; careful follow-up and minimization of strenuous activity is required.
- All surgical procedures entail risk, and any intervention designed to heal a chronic wound may risk further wound formation and exacerbation.

Patient Education Points



- Surgical interventions for chronic wounds generally do not address the underlying etiology of disease; therefore, they represent a treatment, rather than a cure.
- Given the lengthy process of healing needed postoperatively, patients should be highly motivated and educated regarding the planned procedure.

Billing Pearls



- Most therapies for chronic wounds may be billed using the standard code sets for flaps and grafts.
- These procedures usually have 90-day global periods; therefore, care should be taken when billing for additional procedures and visits in the postoperative period.

CHAPTER 53 Chronic Wounds

INTRODUCTION

Chronic wounds are a common problem, and pose a significant economic and healthcare burden. All wounds develop from a variety of etiologies and mechanisms, including surgery, trauma, burns, pressure, and disease states such as venous insufficiency, diabetes mellitus, peripheral arterial disease, rheumatologic diseases, and autoimmune disease.¹ Wound healing is a well-defined process comprised of four overlapping phases: hemostasis, inflammation, proliferation, and remodeling.^{2,3} It involves a highly regulated, coordinated effort of many cell types, cytokines, growth factors, extracellular matrix (ECM) substances, and proteases to restore the integrity and function of the skin.⁴ A chronic wound results when any one of these phases is disrupted or prolonged, resulting in an unfavorable wound microenvironment and delayed wound healing.^{3,5}

At the cellular and molecular level, factors that contribute to delayed wound healing include fibroblast and keratinocyte senescence or dysfunction, poor oxygenation, alterations in levels of cytokines and growth factors, abnormal matrix metalloproteinase (MMP) activity, infection, alterations in bacterial load and biofilm development, and chronic inflammation.^{4,5} Chronic wound management is aimed at restoring the wound environment to that of an acute, healing wound, where proliferation, cell migration, and remodeling can occur.¹ Myriad surgical treatment options for chronic wounds are available, including debridement, skin grafting, skin substitutes, shave therapy, and V-Y flaps.

DEBRIDEMENT

Introduction

Debridement is the process of removing necrotic tissue and cellular debris that may impede normal healing.⁶ Several methods of debridement exist, including surgical, autolytic, enzymatic, mechanical, and biologic. The use of debridement as a standard procedure in the management of chronic wounds is based largely on expert consensus rather than randomized controlled trials,⁷ and limited clinical trial evidence for debridement exists.

Importance

Debridement enhances wound healing in various ways, including the removal of nonviable or infected tissue. Left in wounds, necrotic tissue may serve as a nidus for the proliferation of bacteria and subsequent infection.⁸ Bacteria produce biofilms as a means of protection from the host inflammatory response during the wound healing process.⁹ The establishment of a biofilm within a wound hinders wound healing by creating a physical barrier to reepithelialization and through the release of waste products that induce a state of chronic inflammation.¹⁰ Once reaching critical level of colonization, local tissue damage ensues due to elevated levels of toxins and inflammatory cytokines.¹¹ A bacterial concentration of greater than 10^5 bacteria per gram of tissue has been shown to reduce skin graft adherence and graft success.^{12,13}

Debridement also facilitates the growth of a nonhealing wound edge via removal of senescent fibroblasts from the wound base and nonmigratory keratinocytes from the wound edge.^{6,7} Abnormal nuclear expression of β -catenin in keratinocytes at the wound edge leads to the expression of c-myc, resulting in impaired keratinocyte function (differentiation, growth, and migration).¹⁴ In addition, microarray analysis of the wound edge of nonhealing ulcers showed a reduction in epidermal growth factor receptors, diminishing the response of keratinocytes to epidermal growth factor itself. Fibroblasts grown from the base of chronic wounds have also been shown to migrate slower than those from adjacent, intact skin and are less responsive to growth promoting factors.¹⁵ The removal of these senescent cells through debridement makes way for new keratinocytes and fibroblasts to promote reepithelialization and wound closure.⁷

Finally, debridement creates a new wound, and platelets recruited to the site of injury function not only to control hemorrhage, but also to initiate the first phase of wound healing. Platelets release multiple growth factors, including platelet-derived growth factor (PDGF) and transforming growth factor-beta (TGF-beta) which mediate the inflammatory phase of wound healing.⁸

Surgical debridement

Surgical or sharp debridement involves the removal of devitalized tissue using sharp instruments such as scalpels, curettes, scissors, and forceps. This procedure may be performed in an office setting, though select extensive cases may be better suited for the operating room (Fig. 53-1). Surgical debridement is fast and selective, permitting the removal of unhealthy, necrotic tissue while leaving viable tissue intact. It also offers the advantage of accurate assessment of wound size and depth and the presence of tunneling and undermining.⁷ Excision of the overlying nonviable tissue also allows for the attainment of deep tissue biopsy specimens for culture and sensitivity, and the clinical identification of osteomyelitis, which can be present in as many as 85% of cases with positive probing to bone.^{16,17} An adequate vascular supply is required for a successful procedure.

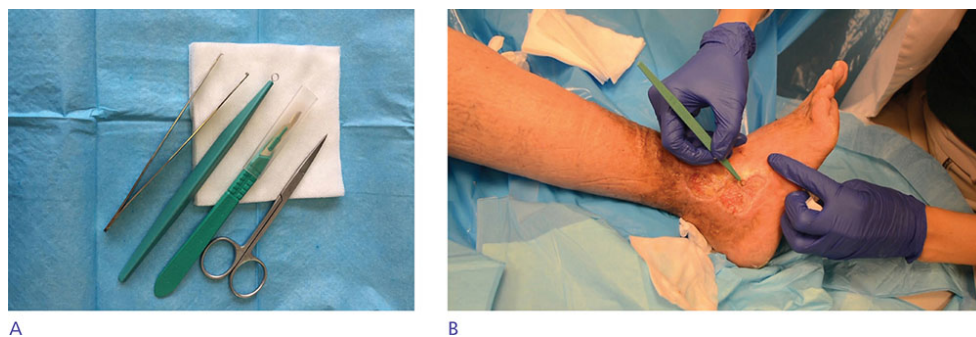


Figure 53-1. Debridement is a straightforward approach to chronic wound care. (A) A simple set of instruments may be used for debridement, including forceps, curette, scalpel, and scissors. (B) Curettage of necrotic and devitalized tissue may be performed both over the center of the wound and around the wound edges.

Surgical debridement is included in multiple algorithms for the treatment of chronic wounds, though sound evidence for its success is lacking.

Treatment guidelines for diabetic foot ulcers (DFUs), for example, include surgical debridement as part of their standard of care.¹⁸ In addition to necrotic tissue excision, removal of callus at each visit reduces plantar pressure and shear forces that may perpetuate ulcer development.⁹ A secondary analysis from a randomized controlled trial comparing topically applied recombinant human platelet-derived growth (rhPDGF) and vehicle (placebo) in patients with DFUs showed higher healing rates in centers that had higher debridement rates.¹⁹

In a prospective study by Williams et al., 55 patients with recalcitrant chronic venous leg ulcers (VLUs) were enrolled to evaluate the effect of sharp debridement on the progression of their wounds over a 12-month period. At 4 and 20 weeks postdebridement, there was a statistically significant reduction in mean surface area in the debridement group and a higher rate of complete healing when compared to patients who did not undergo debridement.²⁰

A retrospective study to determine a correlation between serial debridement of DFUs and VLUs and healing outcomes was performed based on the results of two prospective randomized controlled trials investigating the effects of novel topical wound treatments. This showed a statistically significantly greater median reduction in wound surface area in debrided VLUs as compared to VLUs without debridement, and centers with more frequent debridement had statistically significantly higher rates of wound closure in both the DFU and VLU study.²¹ Still, more research is needed, as most existing studies are not randomized controlled trials.

Indications

Surgical debridement is indicated for medically stable patients who have wounds with an adequate blood supply.²² Surgical debridement should be considered over other less aggressive forms of debridement if larger amounts of necrotic tissue or thick, adherent eschar are present. It is also indicated to quickly remove tissue in urgent cases, such as in settings of an infected wound, necrotizing fasciitis, or sepsis.^{6,16}

Contraindications

Wounds with inadequate circulation should not be debrided, as removal of bleeding tissue in these cases is contraindicated.²² Surgical debridement

should be avoided in patients with vascular insufficiency, such as ischemic limbs, and in stable, poorly perfused heel ulcers, unless infection is suspected.^{6,23} Debridement of wounds due to pyoderma gangrenosum is also contraindicated due to pathergy, leading to induction and exacerbation of existing ulcers with trauma.²⁴ Debridement should be performed with caution in the setting of clotting disorders or anticoagulants use.⁶

Technique

Office-based surgical debridement requires the use of sharp surgical instruments including forceps, scalpels, curettes, and scissors. Toothed forceps are useful, as they permit the grasping of necrotic tissue while minimizing trauma to normal skin. A number 10, 15, or 21 blade scalpel may be used to remove thin layers of unwanted tissue until reaching a healthy, well-perfused base. Scalpel blades may need to be replaced during the procedure. Sharp scissors are also useful for dissecting and excising thick eschar and necrotic tissue. Curettes work well for removing proteinaceous slough, typically yellow to brown in color and filled with bacteria and proteases that accumulate over the wound bed.^{7,25}

Except in patients with significant neuropathy, premedication with a topical or local anesthetic may be required. Lidocaine-prilocaine cream (eutectic mixture of local anesthetics [EMLA]; AstraZeneca, Wilmington, DE) is the only evidence-based topical anesthetic indicated for debridement of lower extremity ulcers. In randomized controlled trials, EMLA led not only to improved pain control in leg ulcers, but also aided mechanical debridement as measured by shortened time to a clean ulcer.^{26–29} It should be applied at least 20 minutes prior to debridement to achieve analgesia.⁷ For more aggressive in-office debridement, a ring block with lidocaine is another option.²⁵

The goal of debridement is to obtain a clean, well-vascularized wound bed, transforming a chronic wound into an acute wound capable of progressing through the phases of healing normally.³⁰ In chronic wounds, only nonviable, nonbleeding tissue should be removed,²² which is often brown or black in color.⁷ It is sometimes clearly demarcated from viable tissue and can be dissected along that line of demarcation. If unable to clearly distinguish healthy from devitalized tissue grossly, thin sections of tissue should be excised until reaching clearly viable tissue. Viable tissue

should demonstrate punctate bleeding and no clotted venules along the wound edge.²⁵

There is no clear guideline on the extent to which a wound should be debrided, though nonhealing edges of wounds have distinctly different gene expression profiles than viable adjacent skin.¹⁵ For successful debridement, the excision must include a margin of response of cells that are healthy enough to respond to wound healing stimuli.³¹ Saap and Falanga developed a Debridement Performance Index to determine the adequacy of debridement of DFUs. This scoring system was found to be an independent predictor of wound closure in their study, including the presence of callus, undermining, and wound bed necrotic tissue as scoring parameters.³² The same researchers later developed a Wound Bed Scoring System using healing edges, presence of eschar, greatest wound depth/granulation tissue, amount of exudate, edema, periwound dermatitis, periwound callus and/or fibrosis, and a pink/red wound bed as parameters. Higher scores correlated with better healing outcomes.³³

Complications and limitations

As with any operative procedure, there is risk of introducing infection and the expansion of a nonhealing ulcer. Intolerable pain may complicate surgical debridement, and such cases may be better suited for management in the operating room under general anesthesia.²⁵ In cases with a large wound surface area, bedside debridement may be inappropriate due to inability to assure anesthesia and the risk of uncontrollable bleeding, and should be reserved for the operative setting for better hemostatic control. Bedside debridement is also inappropriate for cases where debridement of deeper structures such as tendons, bone and vascular structures are involved, and in cases where emergent surgery is required, such as with sepsis.³⁰

Follow-up care

Improvement following debridement may not be apparent until 2 to 4 weeks postoperatively. However, debridement is typically not a one-time event, as many wounds require repeated debridement to maintain a wound environment conducive to healing.⁶ One study showed greater healing rates were associated with higher debridement rates,¹⁹ while another study demonstrated no statistically significant correlation between frequency of

debridement and higher rates of wound closure, though there was some evidence of a beneficial effect in DFUs.²¹ Wilcox et al. performed a recent retrospective cohort study with the largest data set to date, including 154,644 patients with 312,744 wounds of all causes, to investigate healing outcomes with debridement frequency. The results showed that frequent debridement was associated with shorter healing time.³⁴ In a retrospective cohort study by Warriner et al., more frequent visits and sequential debridement translated into increased healing, lower costs, and better quality of life for patients with DFUs and VLUs.³⁵ In general, an Unna boot or other compressive approach is required for any treatment for lower extremity chronic wounds (Fig. 53-2).



Figure 53-2. Unna boot placement step-by-step. (A) A specialized Unna boot and cohesive bandage may be used for placement. (B) and (C) The first layer is placed using a loose overwrap technique that permits gentle coverage without compression. (D) At this point the entire lower extremity is covered with the first layer. (E) The cohesive bandage is then wrapped over the dressing and (F) a final layer of compression is then placed.

Nonsurgical methods of debridement

Autolytic

Autolytic debridement is the most natural and selective form of debridement. During the inflammatory phase of wound healing, serine proteases and MMPs are released by neutrophils to degrade devitalized and foreign material.³⁶ Autolytic debridement takes advantage of this natural process, and is performed through the use of occlusive moisture-retentive dressings that provide an optimal wound environment for endogenous proteolytic enzymes to degrade devitalized material.^{6,7}

Occlusive dressings increase the rate of wound healing; in a porcine model, partial-thickness wounds covered with a polyethylene film were found to heal twice as quickly as uncovered wounds.³⁷ These results were later corroborated in a similar study involving partial-thickness wounds in healthy human subjects.³⁸ In a prospective study by Nemeth et al., patients who received either shave or 3-mm punch biopsies were treated with either an occlusive hydrocolloid dressing or by conventional wound therapy. Occluded wounds were more likely to heal than controls, and the treatment group was less likely to experience pain in comparison to the control.³⁹ In another prospective study involving chronic wounds, a hydrocolloid/alginate spiral dressing and hydrocolloid secondary dressing was used in the management of stage III and IV pressure ulcers. Both ulcers which were surgically debrided prior to the study and those that were not had decreased amounts of fibrin slough and necrotic tissue on study completion.⁴⁰ In another randomized controlled trial, autolytic debridement of chronic leg ulcers had similar efficacy to a commercially available enzymatic debriding agent, determined by reduced amount of eschar and fibrous slough and increased granulation tissue and reepithelialization.⁴¹

The major categories of occlusive dressings used for autolytic debridement include polymer films, polymer foams, hydrogels, hydrocolloids, and alginates. Individual wound characteristics dictate the choice of a particular dressing to ensure maintenance of moisture balance. Polymer films, hydrogels, and hydrocolloids maintain a moist environment, while foams and alginates have absorbent properties.⁴² However, combinations of these products may be utilized to promote a moist

environment while protecting the surrounding tissue from excess moisture.⁷ Autolytic debridement should not be used in patients with infected wounds or deep wound cavities. Dressings are typically left on for 2 to 3 days and should be irrigated with normal saline upon removal to discard the liquefied necrotic debris.

Autolytic debridement confers the advantage of being generally pain-free. However, it is slower than other forms of debridement, and multiple rounds of dressing application and irrigation may be required to elicit the desired effect.⁶ Autolytic debridement also does not debride cells deep in the wound bed or wound edge. Another drawback is the possibility of maceration of surrounding healthy skin.⁷ On each dressing change, wound fluid should be examined for signs of infection, including purulence and odor, and the patient should be assessed for inflammation and increased wound pain. If infection is suspected, autolytic debridement should be discontinued and a more rapid form of debridement, such as surgical debridement, should be employed to avoid aggravating the infection and adversely affecting the healing process.⁶

Enzymatic (Chemical)

Enzymatic or chemical debridement involves the topical application of exogenous enzymes onto the wound bed to dissolve slough and devitalized tissue. Collagenase is a selective enzyme derived from the bacterium *Clostridium histolyticum*. It is more effective at degrading collagen and elastin⁴³ and has been shown to increase endothelial and keratinocyte migration.⁴⁴

Enzymatic debridement has the advantage of ease of use compared to other forms of debridement. Collagenase typically requires once-a-day application.^{6,7} Collagenase is also relatively safe, though there have been reports of transient erythema if collagenase application is not confined to the wound bed.^{6,43} Products containing heavy metals, such as silver sulfadiazine, should not be used in conjunction with collagenase, as they have an inactivating effect.⁶

Mechanical

Mechanical debridement is the use of force to remove loose, devitalized tissue. It is a nonselective form of debridement, as it could potentially harm viable tissue, and may be associated with pain.²³ Wet-to-dry dressings

changes are the most common technique, and are useful in the removal of fibrin from wounds. This method involves the application of a saline-moistened gauze onto a wound, letting it dry, and removing the dry gauze from the wound. It is usually repeated once or twice daily; it is discontinued and switched to an advanced wound dressing once a clean, granulating base is reached.^{7,8} However, wet-to-dry dressing removal can be very painful, requiring premedication, and may cause bleeding and damage to viable, newly formed skin.⁸ Mechanical debridement does not debride cells at the wound edge.

Mechanical debridement may also be accomplished by other means, including forceful irrigation via pulsed lavage, whirlpool therapy, or ultrasonography.^{6,23} Pulsed lavage involves flushing a wound with saline at no more than 15 psi of pressure using a syringe to drive out necrotic debris. Whirlpool therapy is offered at certain facilities, using fast-moving water to remove loose debris, though this method poses concerns with risks of contamination and infection.⁶⁻⁸ A novel form of mechanical debridement involves the use of low-frequency ultrasound for the mechanical debridement of wounds, though trials demonstrating its efficacy are pending.⁴⁵

Biologic

The use of maggots for debridement is an early practice that has reemerged as a method to rapidly debride chronic wounds. Sterilized, medical-grade *Lucilia sericata*, *Phaenicia sericata*, and *Lucilia cuprina* maggots are usually reserved for debridement of intractable wounds with abundant fibrinous material.²³ The larvae secrete enzymes in their saliva that work to liquefy necrotic tissue.⁴⁶ Maggot therapy should not be used in patients with life- or limb-threatening infections, issues with hemostasis, or deep tracking wounds.⁴⁷ Barriers to use include patient and provider psychological distress as well as pain, which was demonstrated in a recent randomized controlled trial.^{23,48} Biologic debridement using maggot therapy has been shown to reduce time to debridement, though it has not proven to positively impact healing.^{49,50}

SKIN GRAFTING

Introduction

Skin grafting is another approach to chronic wound management.⁵¹ The earliest reports of skin grafting occurred almost 3,000 years ago when Hindu surgeons used skin from the gluteal region to repair nose and ear defects from mutilation practices.^{52,53} Major advances have taken place over the past two centuries.^{52,54} Grafts are generally categorized based on thickness, including split thickness, full thickness; composite grafts are used infrequently for chronic wounds.^{51,55}

Healing of skin grafts occurs via progression through three stages over a course of days to months. The first stage is imbibition, or the ischemic period, where fibrin acts as a glue to hold the graft in place, and the graft receives nutrients through passive diffusion. This is followed by inosculation, where revascularization occurs through the connection of blood vessels in the wound bed to vessels in the dermis of the graft. The third stage is neovascularization, where capillaries grow into the graft bed and lymphatics are reestablished.⁵⁵ Throughout these stages, epidermal proliferation, hyperplasia, and reinnervation are occurring. Revascularization is achieved by days 4 to 7 posttransplantation, and reinnervation occurs within 2 to 4 weeks, but may take months before achieving maximal healing.⁵⁶

Split-thickness skin grafting

Split-thickness skin grafting (STSG) is the gold standard of treatment for major loss of skin.⁵⁷ STSG is comprised of the epidermis and part of the dermis.^{56,58} STSG can be divided into three categories based on thickness of the graft—thin (0.005–0.012 in), intermediate (0.012–0.018 in), and thick (0.018–0.030 in).⁵⁸ In a prospective, case-controlled study of STSG compared to conservative wound dressing in DFUs, mean healing time was significantly less in the STSG group compared to the control group.⁵⁹ Dermal thickness included in STSG is inversely related to scarring and wound contracture of the graft site.⁶⁰ One study evaluated the effectiveness of excision with STSG on healing in 357 patients with chronic legs ulcers of various etiologies. At 1 year, 64% of the patients had maintained wound healing. Healing rates at 1 year for each etiology were as follows: venous—

64%, venous/ischemic—60%, arterial—20%, traumatic—86%, vasculitis—43%, and miscellaneous—75%.⁶¹

Indications

STSGs are indicated when there is a defect in the skin or soft tissues where healing by secondary intention is expected to be too slow because of the refractory nature of the wound or the size of the wound.^{60,62} STSGs are more likely to take than FTSGs, though they typically produce a less favorable cosmetic result.⁵⁵ While radiated skin previously had graft failure rates ranging from 30% to 100%, improvements in surgical and wound healing techniques have produced more favorable outcomes.^{63–66} For example, in patients who had received radiation therapy preoperatively, STSGs in conjunction with vacuum-assisted closure (VAC) therapy resulted in 71% graft take.⁶³

Contraindications

Contraindications are the presence of poor blood supply to the wound bed, infection, and exposure of bone, tendon, vessels, nerves, or implants without soft-tissue coverage.^{55,67}

Procedural Technique

Several considerations should be taken into account when choosing a donor site for STSG, including the size of the defect to be covered, ease of wound care to the donor site, visibility of scar, and the similarity to graft site in color, texture, and presence/absence of hair.^{58,68,69} While STSGs can be taken from anywhere on the body, some locations are preferred.⁶² The proximal anterior and lateral thigh as well as the proximal inner arm are commonly chosen donor sites, as the locations are easy to cover with clothing and cause minimal discomfort during reepithelialization.⁵⁸ The ipsilateral buttocks is another commonly used donor site, though there may be more pain associated with healing than occurs on other locations.

In order to maximize graft success, the recipient site should have a healthy, granulating wound bed and a low bacterial load, ideally less than 10.⁷⁰ The wound bed should be prepared appropriately, including removal of necrotic tissue, prior to skin grafting. Underlying medical comorbidities such

as diabetes mellitus and hypertension should be optimized prior to the procedure.

Once the appropriate form of anesthesia is induced and a sterile field has been prepared, the skin graft can be harvested from the donor site.⁶¹ A dermatome is one of the most commonly used methods as it has an oscillating blade that consistently harvests tissue with uniform thickness.^{61,71} The thickness, width, and length can each be adjusted based on recipient site need. A carrier, meshing device, or scalpel can be used to mesh the skin obtained with the dermatome in order to cover more surface area.⁶¹ Meshing allows for up to nine times more surface area coverage as well as drainage of fluids. Fluid buildup under sheet grafts may lead to graft failure. For areas such as the face, neck, hands, and joints, sheet grafts are preferred over meshed grafts as they demonstrate less contraction and better cosmetic outcomes.⁷²

The graft is placed dermis-side down over the prepared wound bed and is secured in place, usually using sutures. Bolster dressings are helpful in preventing hematoma formation.⁵⁵ The original dressing should be left in place for the first 3 to 7 days unless there are signs of complications or infection such as excessive pain, odor, or exudate.⁵⁸

For the donor site, a semi-occlusive dressing that promotes a moist wound environment has been shown to significantly decrease pain and time to wound healing.^{58,73} Typically, the donor site heals in several weeks through reepithelialization. During this period, daily wound care and dressing changes are important to minimize the risk of infection and maximize healing. The donor site often leaves a permanent scar and discoloration.⁶²

Complications and limitations

Complications include loss of the graft, bleeding, infection, poor wound healing, and pain. Loss of graft can be due to a variety of factors including friction, pressure, insufficient blood supply, hematoma, seroma, and infection.^{1,56} Sheet grafts are more susceptible than meshed grafts to hematoma formation since they do not have fenestrations to allow for drainage of fluid.⁷² Pain associated with healing of the donor site can be significant, as nociceptive pain fibers are activated in proportion to the size of the wound created. Furthermore, the inflammatory response that occurs during wound healing augments pain.⁷⁴

Limitations of STSG include donor-skin availability, high rate of graft failure, and its operator dependence.^{1,57,58} Use of STSGs results in the creation of a second wound, the donor site, thereby incurring the risks associated with a new wound (bleeding, pain, delayed wound healing, infection, etc.). When STSGs are used in the closure of full-thickness skin defects, scarring and wound contracture can occur.⁷⁵ Additionally, they may be hypo- or hyperpigmented in relation to surrounding skin and lack hair.⁵⁸

Follow-up care

Instruct the patient to keep the dressing dry and leave it in place for 1 week. During this time, minimizing shearing forces and strenuous activity is important to reduce bleeding and trauma at the graft site. On postoperative day 7, the patient will return to the clinic or hospital for the first follow-up visit. A healthy graft will look pink to violaceous. It can be gently cleansed with sterile saline before applying petrolatum to the wound and covering it with gauze secured by tape. This should be kept dry and in place for 2 to 3 days, at which point the patient may begin personal wound care. The patient should be instructed to clean the wound gently twice daily, before covering it with petrolatum and a bandage. At 3 weeks after the procedure, the patient is not required to cover the site. At 1 month after the procedure, the patient may treat the skin normally.⁷⁶

Full-thickness skin grafting

Full-thickness skin grafts (FTSGs) are comprised of the entire epidermis and dermis including adnexal structures such as hair follicles, sebaceous glands, eccrine glands, and nerves.^{56,58} FTSGs are the most commonly used skin graft,⁵⁵ though due to the need for a clean, well-vascularized wound bed, FTSGs are more often used for acute, as opposed to, chronic wounds.

Indications

Though FTSGs are indicated when there is a full-thickness skin or soft-tissue defect in which healing by primary closure, granulation, or a flap is not optimal,^{54,55} FTSGs are not the preferred method for chronic wounds as high rates of graft failure may occur in this setting.⁶⁹

Contraindications

Contraindications are the presence of poor blood supply to the wound bed, infection, and exposure of bone, cartilage, or implants without soft-tissue coverage, as they are poorly vascularized and not conducive to graft take.^{55,67}

Procedural technique

The technique for FTSGs is similar to STSG, though the graft is harvested as a full-thickness excision and the donor site is generally closed primarily. Additionally, the graft is defatted prior to placement on the wound bed. Simple interrupted sutures are generally used to secure the graft in place.⁵⁵

Complications and limitations

FTSG complications and limitations are similar to STSG, as they are susceptible to loss of the graft, bleeding, infection, poor wound healing, pain, and hematoma or seroma formation.⁵⁵ FTSGs are limited in the surface area that can be taken from the donor site, and therefore they are not a viable option for very large wounds.⁶⁰ There is a higher incidence of necrosis and graft failure with FTSGs than with STSGs due to the higher metabolic demand of thicker grafts.^{55,58}

Follow-up care

Follow-up care is similar to that utilized for STSG.⁷⁶

SKIN SUBSTITUTES

Introduction

Skin substitutes are utilized as adjunctive therapies in the management of hard-to-heal wounds of varying etiologies.⁷⁷ Cellular skin substitutes are thought to provide cells and growth factors necessary for normal healing that may be aberrantly regulated in the hostile inflammatory environment of chronic wounds. They also act as temporary scaffolds for cellular migration and proliferation by providing ECM elements to otherwise deficient wounds.⁷⁸ Skin substitutes can be divided into cellular and acellular matrix products. Cellular matrices, or living skin equivalents, in theory contain a biologic (i.e., animal-, human-, or plant-derived) or synthetic scaffold laden

with biologically active allogeneic fibroblasts and/or keratinocytes. Acellular matrices may be synthetic, biologic, or composite, and lack living cells.^{79,80} Acellular matrices offer the theoretical advantage of being less inflammatory or immunogenic, as they lack cells that may trigger a response leading to graft failure.⁸⁰ There are numerous, well-studied, and commercially available skin substitutes (Tables 53-1 and 53-2). This section addresses the technique of application of two common products, a bilayered living cellular construct (BLCC, Apligraf[®], Organogenesis, Canton, MA) and a porcine small intestine submucosa (PSIS, Oasis[®], Smith and Nephew, Largo, FL).

Table 53-1. Evidence for Cellular Matrix Products

Matrix Name	Source	Indication	FDA Approval	RCT Outcomes
Bilayered Cellular Construct (Apligraf, Organogenesis, Canton, Mass)	Epidermal part: keratinocytes Dermal part: bovine type I collagen, human neonatal foreskin fibroblasts	VLUs, DFUs, burns, acute wounds, postradiation ulcers, epidermolysis bullosa, pyoderma gangrenosum	Noninfected partial and full-thickness VLUs of > 1 month duration. Full-thickness DFUs of > 3 weeks duration that do not involve tendon, muscle, joint capsule, or bone	VLUs: At 6 months, over 69% of patients healed compared to 49% in those receiving compression alone. Most beneficial in VLUs > 1 year duration; at 24 weeks achieved closure in 47% of patients compared to 19% in those receiving compression. ⁸¹ DFUs: At 12 weeks, 67% achieved closure compared with 38% of patients on conventional therapy alone ⁸²
Collagen Dermal Matrix (Dermagraft, Organogenesis, Canton, MA)	Human neonatal foreskin fibroblasts cultured onto a bioresorbable glycolic acid scaffold (polyglactin 910)	Full-thickness DFUs present >6 weeks which extend through the dermis	Full-thickness neuropathic DFUs of >6 weeks duration that do not involve tendon, muscle, joint capsule, or bone	Significantly higher percentage of DFU patients (30%) achieved wound closure at week 12 compared to those receiving standard wound care alone (18.3%) ⁸³
Dehydrated Human Amnion/Chorion Membrane (Epifix, MiMedx Group Inc., Marietta, GA)	Single layer of epithelial cells, basement membrane, and avascular connective tissue matrix	DFUs, VLUs, chronic vascular ulcers, partial- and full-thickness wounds, pressure ulcers, surgical wounds, trauma wounds, and third-degree burns	Regulated by the FDA as banked human tissue	VLUs: Those treated with Epifix and compression had greater wound size reduction compared to those treated with compression alone. At 4 weeks, 62% showed 40% wound closure compared with 32% in controls ⁸⁴ DFUs: At 12 weeks, 97% reached wound closure compared to 51% in those treated with standard therapy alone ⁸⁵
Cryopreserved Placental Membrane (Grafix, Osiris Therapeutics, Inc., Columbia, MD)	Mesenchymal stem cells, neonatal fibroblasts, epithelial cells, growth factors and angiogenic factors	Acute and chronic wounds including DFUs, VLUs, pressure ulcers, burns, surgical wounds, pyoderma gangrenosum, and epidermolysis bullosa	Regulated by the FDA as a human cell, tissue-based product, under 21 CFR 1271, part 361	Significantly higher percentage of DFU patients (62%) achieved wound closure at week 12 compared to those receiving standard wound care alone (21%) ⁸⁶

Table 53-2. Evidence for Acellular Matrix Products

Matrix Name	Source	Indication	FDA Approval	RCT Outcomes
Dermal Regeneration Matrix (Integra, LifeSciences, Plainsboro, NJ)	Epidermal part: semipermeable polysiloxane (silicone) Dermal part: Cross-linked bovine tendon collagen and glycosaminoglycan	Partial- and full-thickness wounds including pressure ulcers, VUs, DFUs, surgical wounds, chronic vascular ulcers, second-degree burns, and draining wounds	FDA-approved (510[k] for DFUs)	DFUs: Complete closure was achieved in 51% of patients compared to 32% in controls. Faster closure was also observed at 43 days vs. 78 days in controls ⁸⁷
Porcine Small Intestinal Submucosa (Oasis, Smith & Nephew, Inc., Largo, FL)	3-dimensional ECM derived from porcine small intestinal submucosa	Partial- and full-thickness wounds, DFUs, VLUs, pressure ulcers, chronic vascular ulcers, traumatic wounds, second-degree burns, and surgical wounds	510(k) cleared medical device	VLUs: At 12 weeks, 55% of patients healed with Oasis plus compression compared to 34% in patients treated with compression alone ⁸⁸ DFUs: At 12 weeks, 54% healed compared to 32% in patients receiving standard wound care alone ⁸⁹
Cadaveric Allograft (ALLODERM™ Regenerative Tissue Matrix, LifeCell, an ACCELITY company, Branchburg, NJ)	Processed cadaveric human skin without epidermal cells	Damaged or inadequate integument in surgical wounds from abdominal wall and breast reconstruction	Regulated by the FDA as human tissue for transplantation	DFUs: Application in conjunction with mineral oil-soaked fluff compression dressing achieved closure by 16 weeks in 86% of patients compared to 29% in control patients ⁹⁰
Poly-N-acetyl Glucosamine (Talymed Marine Polymer Technologies, Inc., Danvers, MA)	Poly-N-acetyl glucosamine shortened fibers derived from microalgae	Partial- and full-thickness wounds, DFUs, VLUs, pressure ulcers, mixed vascular ulcers, chronic vascular ulcers, abrasions, second-degree burns, post-Mohs surgery, and post-laser surgery	FDA approved (510[k])	VLUs: At 20 weeks 45% healed completely after receiving one application, 86.4% of patients healed after receiving it every 2 weeks, 65% of patients healed with application every 3 weeks, and 45% healed with standard wound care alone ⁹¹

BLCC

BLCC is a living, bilayered cellular construct. Its epidermal equivalent is composed of a stratified layer of human neonatal keratinocytes, while the underlying dermal layer is comprised of bovine type I collagen and human neonatal fibroblasts (Fig. 53-3).^{78,92}



Figure 53-3. Bilayered skin construct placement step-by-step. (A) The surgical tray with the bilayered skin substitute is arranged. (B) The skin substitute is placed on a piece of gauze. (C) The skin substitute is gently scored and then (D) trimmed to fit the wound while on the gauze. (E) It is then applied to the wound. (F) Appearance after the wound has been covered with the skin substitute. (G) The skin substitute is gently taped in position and then (H) secured with an absorbent dressing.

Indications

BLCC is indicated, in conjunction with standard of care therapy, for the treatment of noninfected, partial- and full-thickness VLU of greater than 1 month duration, and full-thickness DFUs of greater than 3 weeks duration

without exposed tendon, muscle, capsule, or bone, which have not adequately responded to standard therapy alone.⁹³ In a randomized controlled trial for VLUs, BLCC healed over 63% of patients at 6 months compared to 49% of patients receiving standard compression therapy. However, BLCC had even greater benefits in long-standing VLUs of greater than 1 year duration, reaching 47% wound closure at 24 weeks compared to 19% in controls.⁸¹ In a randomized controlled trial for DFUs, 56% of patients achieved wound closure by 12 weeks compared to 38% of patients receiving only offloading and debridement.⁸² BLCC has, however, also been utilized in the treatment of burns, surgical wounds, radiation ulcers, and conditions such as epidermolysis bullosa and pyoderma gangrenosum.^{78,94}

Contraindications

Contraindications include infection, known allergy to bovine collagen, and known hypersensitivity to components of the agarose shipping medium.⁹³

Procedural technique

BLCC is supplied in a circular disc. The product should be stored at 20° to 23°C in its air-sealed bag containing 10% CO₂/air mixture and nutrient medium. The matrix should be handled using an aseptic technique. Upon uncovering the disc, gauze may be placed over the matrix and moistened with a few drops of normal saline to aid in removal of the matrix from the medium. Surgical forceps allow for ease of removal of the matrix onto the moistened gauze while leaving it intact and separating it from the medium. The matrix may then be perforated using a scalpel before application to allow for drainage. The graft can be cut using scissors while on the gauze to better conform to the wound shape and to trim excessive product. The matrix can then be placed over a clean and properly debrided wound base. Placing the gauze over the wound with the graft down will allow the matrix to remain in the proper orientation, with the dermal layer facing down. The gauze can then be removed and the matrix can be evenly spread over the wound bed; any bending and folding should be corrected using a cotton tip applicator. Secure the product in place using adhesive strips and then cover it with a nonadherent dressing, followed by the appropriate secondary dressing.^{78,92,93}

Complications and limitations

Various adverse events have been reported, including suspected wound infection, cellulitis, exudate, and pain. Heavy exudate may cause the matrix to lift off the wound bed, reducing its effectiveness.⁹³

Follow-up care

Patients should be followed at least once per week for visualization of the matrix, though the secondary dressing may be changed as needed. Adherent pieces of the matrix should be left in place, while nonadherent remnants may be removed. Reapplication may be necessary; data have supported the safety and efficacy of up to five applications. Patients should be counseled to continue compression therapy in the case of VLUs, and pressure-offloading in the case of DFUs, as BLCC does not address the underlying pathophysiology of these entities.⁹³

PSIS

PSIS is a three-dimensional acellular matrix derived from porcine small intestinal submucosa. It is a skin substitute that acts as a scaffold to promote cellular migration, wound bed granulation, and revascularization.^{88,95} It may be stored at room temperature for up to 2 years.⁹⁶ A randomized, controlled trial evaluating the effectiveness of PSIS with compression therapy versus standard wound care (compression therapy alone) in the treatment of chronic VLUs found that a greater proportion of wounds were healed by 12 weeks in the PSIS group (55% of the PSIS group compared to 34% of the standard wound care group).⁸⁸

Indications

PSIS is indicated in the treatment of partial- and full-thickness acute and chronic wounds including VLUs, DFUs, pressure ulcers, peripheral vascular ulcers, burns, trauma wounds, draining wounds, and surgical wounds.^{95,96}

Contraindications

PSIS is contraindicated in patients with a sensitivity to porcine material. It is not indicated in the treatment of third-degree burns.⁹⁶ Before application, excessive swelling, bleeding, infection, and exudate should be addressed.^{95,96}

Procedural technique

Prior to application, the wound bed should be prepared appropriately. Necrotic debris and devitalized tissue should be debrided. After measuring the wound the sheet of PSIS is cut to a size that will fully cover the wound bed and extend just past the wound margins using sterile technique. For exudative wounds, a scalpel may be used to fenestrate the PSIS in order to allow for passage of exudate. Place the sheet of PSIS in the wound bed so that it directly contacts the wound and overlaps the wound margin. Secure it in place using either adhesive tape, sutures, or staples. Rehydrate the matrix with sterile saline. In order to prevent the matrix from adhering to the secondary dressing, first apply a nonadherent primary dressing directly over the sheet of PSIS followed by a secondary dressing. The primary dressing can be changed every 7 days and the secondary dressing can be changed as often as necessary.⁹⁶

Complications and limitations

The use of PSIS may be complicated by infection, allergic reaction, swelling, erythema, blister formation, pain, and chronic inflammation.^{95,96}

Follow-up care

The patient should follow-up on day 7, or sooner if necessary. At this time the wound bed can be evaluated for healing and wound measurements may be obtained. As the wound heals with PSIS, a caramel-colored or off-white gel may form on the surface of the wound. This gel should not be removed, as it contains the ECM, and its presence is a sign of incorporation and healing. If the wound is not fully reepithelialized, but is free of signs of infection, a new PSIS matrix can be placed directly over the wound every 7 days.⁹⁶

SHAVE THERAPY

Introduction

Patients with long-standing venous insufficiency often develop significant complications, including lipodermatosclerosis (LDS). A spectrum of disease exists in LDS, characterized by hyperpigmentation, induration, and inflammation of the skin on the legs of patients with venous insufficiency.^{97–}

⁹⁹ Acute LDS may be confused with cellulitis or various panniculitides, as it is characterized by intense pain, induration, warmth, and red or purple scaling plaques usually noted just above the medial malleolus.⁹⁸ Chronic LDS, the stage that is thought to precede ulceration, leads to fibrosis and sclerosis of the lower leg.^{97,98} This results in a hard, woody texture of the involved skin, with hyperpigmentation and the pathognomonic inverted champagne bottle appearance.⁹⁷ It is thought that degree of induration of LDS corresponds with the delayed healing of an associated VLU.³⁹ Though its exact pathogenesis is unclear, LDS is likely linked to fibrinolytic abnormalities, and is thus seen on the legs of patients with venous insufficiency.⁹⁹ Compression is the mainstay treatment of VLUs, and various fibrinolytic therapies may be used as adjuncts in patients with LDS, including stanozolol, oxandrolone, and danazol.¹⁰⁰ However, VLUs may fail conservative management, with the postthrombotic etiology being most resistant to treatment.¹⁰¹

Shave therapy is a surgical technique developed for the treatment of refractory VLUs with accompanying LDS. It was first introduced in 1987 by Quaba et al. as a rapid method to shave and remove LDS in layers with subsequent autograft placement.¹⁰² In a study by Schmeller et al., 80 patients with persistent or recurrent VLUs were treated with shave therapy and evaluated for the short- and long-term effects of treatment. The ulcers of the patients were removed together with the surrounding LDS and then covered with a meshed split-skin graft. The short-term healing rate 3 months postsurgery was 79% in 59 patients, while the long-term healing rate was 88% in 18 patients.¹⁰¹

Indications

Shave therapy followed by STSG is indicated for recalcitrant VLUs with LDS. Without LDS, shave therapy is generally not necessary. It has been used in patients who failed conventional STSG, with circumferential legs ulcers, and with ulcers associated with primary venous insufficiency, postthrombotic syndrome, or mixed ulcers.¹⁰³ It may be combined with other procedures, such as excision of insufficient veins for the reduction of pathological reflux.^{101,103}

Contraindications

Surgery should not be initiated in the case of infection. Patients presenting with erythema, edema, and pain within the ulcer should be treated with antibiotics, and the surgery should be postponed until the infection resolves. Concomitant peripheral arterial disease may restrict the use of compression bandages or stockings following surgery.¹⁰³

Procedural technique

Shave therapy usually requires general or spinal anesthesia, unless the ulcer is small or the LDS does not extend to involve the fascia and subcutaneous tissue, in which case local or tumescent anesthesia may be used. Before beginning, the size of the transplant must be measured, keeping in mind that it must be larger than the initial ulcer size. The area of LDS should be marked with a felt-tip marker. Usually the lateral or medial thigh will serve as the donor site, though if larger grafts are necessary, the buttocks or abdomen may be used. At least 4 months must pass before a prior donor site may be reused.¹⁰³

The STSG is harvested using a dermatome, which can adjust the thickness of the transplant. A 0.3-mm thickness has been noted to be adequate for successful healing, though Schmeller et al. used 0.4- to 0.6-mm thick transplants.^{103,104} Various instruments may be used to remove the LDS, depending of the surgeon's experience.¹⁰³ The use of the Schink Dermatome (Aesculap, Tuttlingen, Germany) has been described in numerous studies.^{103,104}

The entire area of LDS is tangentially removed, layer-by-layer, using the Schink Dermatome, exposing the sclerotic area beneath. The perforating veins are often revealed during the surgery, and bleeding is controlled either by compression and elevation of the leg or by suturing the vessel if bleeding is extensive to minimize the need for cauterization. The ablation process is terminated once the surrounding tissue is soft and less indurated to palpation, indicating removal of LDS. The sclerotic process may extend down to the fascia of the lower leg, though it may be difficult to differentiate from the fascia. In these cases, a thin layer of sclerosis is left overlying the fascia.¹⁰³ Closure is achieved most commonly by STSG from the thigh. Schmeller et al. recommended the use of tissue glue to secure the graft to eliminate the need for suture or staple removal.¹⁰¹

Complications and limitations

There is a risk of blood loss due to vascular manipulation during the procedure, which may require transfusion in severe cases. Damage to underlying and adjacent structures, such as vessels, bony structures, tendons, and muscle, are possible complications. In the case of penetration by the dermatome to the muscle or periosteum, these should be repaired with absorbable sutures immediately.¹⁰³ STSG complications are similar to those described above.

Follow-up care

In a later study by Schmeller et al., the long-term sequelae of shave therapy were evaluated in patients with nonhealing VLU secondary to primary venous insufficiency or postthrombotic syndrome. Thirty-eight percent of their patients had hypoesthesia of the transplanted areas. The healing of patients with primary venous insufficiency was favorable compared to those with postthrombotic syndrome, with healing rates of 76% and 58%, respectively. Recurrence occurred in 33% of cases, though these ulcers were reduced by 80% to 90% of their original size. In some patients, there was a direct correlation between use of compression and avoidance of recurrence, as shave therapy does not address the underlying venous insufficiency. Thus, they stress the importance of patient compliance with compression therapy for optimal long-term results.¹⁰⁴

THE V-Y FLAP

Introduction

Pressure ulcers are one of the most common chronic wounds, affecting up to 5% of hospitalized patients.⁵ They occur due to unrelieved pressure in areas of soft tissue compressed against a bony prominence, leading to eventual local tissue necrosis.¹⁰⁵ The treatment of pressure ulcers depends on their stage, though it should be aimed at reduction of pressure, friction and shearing forces, local wound care, and nutritional support.²³ There are a variety of options for the surgical management of pressure ulcers, ranging

from debridement with direct closure and skin grafting to flap reconstruction.¹⁰⁶

Unlike skin grafts, island pedicle flaps maintain their vascular connection at their base.¹⁰⁷ Local flaps are chosen to cover a primary defect when other options are less feasible due to issues with tension, or anatomical form or function.¹⁰⁸ Muscle and myocutaneous flaps have been the surgical treatment of choice for deep pressure ulcers due to their ability to occupy dead space and provide cushioning and durability over a pressure-bearing area. However, these flaps may result in large amounts of intraoperative bleeding and may sacrifice motor function in ambulatory patients.¹⁰⁹ Reports of success in reconstruction of pressure ulcers are limited to case reports and case series. Furthermore, in a systematic review by Sameem et al., there was found to be no statistically significant difference with regard to complication or recurrence rates among patients with pressure ulcers treated with myocutaneous, fasciocutaneous, or perforator-based flaps.¹¹⁰

The V-Y advancement flap, also known as the island pedicle flap, is a versatile flap with a myriad of applications in dermatologic surgery, from repair of facial defects following excision of skin cancers, to surgical treatment of pressure ulcers.^{111,112} The classic V-Y flap is a fasciocutaneous flap, meaning it can contain any or all of the tissue constituents found between the skin and the deep fascia, and spares the muscle.¹¹³ The general principle involves the creation of a triangular flap that is separated from peripheral skin, forming an island. The vascular supply to the flap remains uninterrupted via a pedicle that retains its attachment to the underlying subcutaneous or myocutaneous tissue.^{108,111} Throughout the decades, modifications to the V-Y advancement technique have been made to better enhance its mobility and utility.^{108,109,114–116}

Indications

In general, surgical reconstruction is only necessary in patients with full-thickness, stage III or IV decubitus ulcers after failure of conservative therapy.¹⁰⁵ The choice of flap should be determined on a case-by-case basis, as the method of reconstruction depends on the size and location of the defect. A fasciocutaneous flap is most appropriate when subcutaneous tissue

loss is minimal, allowing the flap to adequately fill the defect.¹¹⁷ They may also be preferred over myocutaneous flaps in ambulatory patients to prevent motor disturbance.¹⁰⁹

Contraindications

Patients with chronic medical conditions or poor nutritional status may not be candidates for surgical reconstruction, as these conditions may hinder the ability of the individual to heal.¹¹⁸ Muscle spasms could compromise flap healing and should be controlled before planning surgery due to risk of dehiscence. In patients with ulcers in close proximity to the anus, a diverting colostomy should be considered prior to surgery due to the risk of fecal contamination at the wound site. Smoking should also be stopped due to the increased risk of flap failure.¹⁰⁵

When the defect is too large for a local flap, advancement may not be possible, since advancement flaps require a considerable amount of available skin at the base of the planned flap.¹¹⁹ Ulcers with greater depth and larger amount of subcutaneous tissue loss may be better suited for myocutaneous reconstruction.¹¹⁷

Procedural technique

Pressure ulcer reconstruction generally occurs in the operating room under general anesthesia. Before beginning, ulcers are debrided and excised to remove necrotic tissue.¹²⁰ Typically, methylene blue dye is used to mark the ulcer extent and act as a visual aid to complete the excision.¹²¹

Proper preparation is critical to the success of any flap procedure.¹¹⁹ Using a marking pen, two lines should be drawn from the widest portion of the ulcer on either side and should meet at a single point away from the defect, making a V-shape. The two lines should have an angle of approximately 30 degrees between them to ensure the ease of primary closure. The incisions should be made with a scalpel with the aid of tissue forceps with teeth along these two lines. They should extend down to the subcutaneous fat to create a pedicle composed of subcutaneous fat and muscle fibers.^{107,111} The pedicle should be dissected until the flap becomes

mobile.¹¹⁹ The cross-sectional area of the pedicle should be approximately equal to that of the overlying skin in order to preserve perfusion. A triangular island of skin should form that is two to three times as long as the diameter of the primary defect and has a width equal to the largest perpendicular diameter of the wound.¹¹² The flap is then advanced over the primary defect, leaving a secondary defect at the donor area. The flap is then sutured in place and the donor area is closed in a linear fashion.

Complications and limitations

One drawback to the traditional V-Y advancement flap is its relatively limited mobility. In rare cases, it may become clear intraoperatively that a V-Y flap will not be sufficiently mobile to permit defect closure; in such cases, alternative approaches, such as a skin graft, may be explored.¹¹⁹ A retrospective study in spinal cord-injured patients after pressure ulcer reconstruction in patients with either fasciocutaneous or myocutaneous flaps found suture line dehiscence to be the most common complication, followed by infection, hematoma, partial flap necrosis, and total flap necrosis.¹²² In a systematic review including 13 studies of patients treated using fasciocutaneous flaps, the overall complication rate and recurrence rate were 11.7% and 11.2%, respectively.¹¹⁰ Risk factors for dehiscence and recurrence in patients receiving flap therapy for coverage of pressure ulcers in another retrospective study included poor diabetes control, prealbumin of less than 20 mg/dL, history of same-site flap failure, ischial wound location, and young age at surgery time.¹²³

Follow-up care

The postoperative management of pressure ulcers is focused on local wound care to reduce infection, tension, and dehiscence.¹²⁴ Complete immobilization for 3 to 6 weeks is the conventional recommendation to allow the flap to heal and reach an appropriate tensile strength for movement. Sitting therapy can then be initiated, but should progress slowly for the first 2 weeks.¹⁰⁶

CONCLUSIONS

Chronic wounds are a common problem, and are a major source of morbidity and expense in the healthcare system. While standard care for chronic wounds is predicated on several fundamental principles, such as offloading and compression, surgical approaches to these wounds are increasingly used to augment healing and increase the chances that a given wound will heal. A deep appreciation of and familiarity with the full range of surgical and procedural options for chronic wounds is important for the dermatologic surgeon.

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CHAPTER 54 Hidradenitis Suppurativa

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SUMMARY

- Local cure of HS can be accomplished with elective surgical procedures.
- Surgery is indicated throughout all stages of hidradenitis suppurativa, with the exception of the mildest forms.

- Surgical interventions for HS include intralesional injection of triamcinolone, incision and drainage, derroofing, and excisional surgery (including CO₂ laser).

Beginner Tips



- Cryoanesthesia with liquid nitrogen or a refrigerating spray is useful, as the inflamed area is difficult to anesthetize using injectable anesthetics.
- Cryoanesthesia should be performed over the full length of the planned incision or injection site.
- Acute surgical interventions, that is, intralesional injection of triamcinolone and incision and drainage, can be performed to quickly relieve symptoms of inflammatory nodules and tense abscesses.

Expert Tips



- Secondary intention healing is ideal as it obviates the risk of entrapping diseased skin leading to recurrence.
- The extent of sinus tract formation can only be established intraoperatively, and the affected area is often considerably larger than expected based on the preoperative assessment.

- The addition of color Doppler ultrasound may add relevant information prior to surgery.

Don't Forget!



- Photodynamic therapy (PDT) may be useful in the treatment of HS through selective, cytotoxic, and immunomodulatory effects.

Pitfalls and Cautions



- Patients with HS in the perianal or perineal area, especially male patients and those with concomitant intestinal bowel disease (IBD), are at risk of developing fistulas penetrating through the anal sphincter complex or communicating with the rectum. The presence of trans- or intersphincteric sinuses or fistulas should preferably be assessed by endorectal MRI or a fistulogram preoperatively.

Patient Education Points

- Patients should appreciate that HS is a chronic disease, and that any intervention runs the risk of potentially serious side effects.

- To ensure the best patient outcomes, surgeons should select the appropriate surgical technique based upon operator experience and the individual needs of the patient.
- Patients should be highly motivated prior to initiating HS surgery, as recovery times may be protracted and require significant wound care and physical therapy.

Billing Pearls



- Hidradenitis excision may be coded with the 11450-11471 series codes.

CHAPTER 54 Hidradenitis Suppurativa

INTRODUCTION

Hidradenitis suppurativa (HS), also known as acne inversa, is a chronic, recurrent, inflammatory and debilitating skin disease that usually presents after puberty. HS is characterized by painful, deep-seated, and inflamed boils most commonly in the axillary, inguinal, and anogenital regions.¹ HS is a common disease, with an average prevalence of 1% in Europe and a male-to-female ratio of 1:3.²⁻⁴

The pathogenesis of HS is still not completely understood. The disease probably originates from keratinous plugging of the infundibulum, resulting in dilatation and subsequent rupturing of the hair follicle. The expulsion of keratin fibers and commensal bacteria into the dermis upon rupture of the hair follicle leads to a severe foreign-body like immune response, resulting in inflammatory nodules and abscesses.^{1,5} The aberrant healing may lead to sinus tract formation and scarring. Several exogenous factors have been linked to HS such as smoking and obesity.^{2,6} Up to 80% of patients with HS are current or former smokers.⁷

Besides these environmental factors, genetic factors are considered to play a crucial role in the development of HS, with up to 40% of patients reporting a family history of HS in first- and second-degree relatives.^{8,9} Additionally, several mutations have been found in the γ -secretase genes *PSENEN*, *PSEN1*, and *NCSTN* in families with multiple members suffering from HS.^{10,11} However, the phenotype of HS in these families was severe and very atypical, and these mutations could not be verified in larger populations with common HS. In addition, HS is associated with a variety of concomitant

and secondary diseases such as metabolic syndrome, diabetes, inflammatory bowel disease (especially Crohn's disease), and spondyloarthropathy.^{12,13}

To date, there is no long-term cure for this chronic inflammatory disease. Treatment consists of anti-inflammatory medication and surgical management. Surgery is indicated throughout all stages of the disease (Fig. 54-1).¹⁴ The required surgical intervention is chosen based on the nature of the symptoms, the type of lesions, the presence of sinus tracts, and the size of the area. The presence of inflammation and suppuration determines the need for anti-inflammatory treatment (e.g., systemic antibiotics) before surgery. The preceding systemic treatment reduces inflammation and may thereby possibly reduce the affected area, resulting in a less extensive surgery. Surgical interventions for HS include intralesional injection of triamcinolone, incision with drainage, deroofing, and excisional surgery (including CO₂ laser).¹⁴

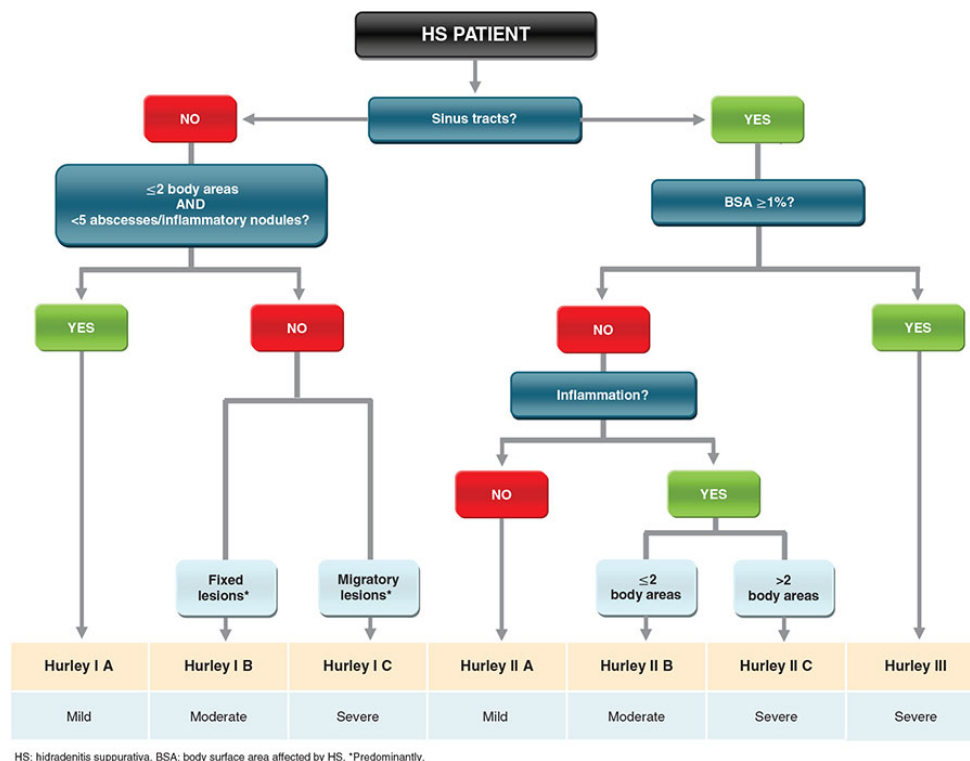


Figure 54-1. Schematic overview of the refined Hurley classification. (Adapted with permission from Horvath B, Janse IC, Blok JL, et al. Hurley Staging Refined: A Proposal by the Dutch Hidradenitis Suppurativa Expert Group, *Acta Derm Venereol.* 2017 Mar 10;97(3):412–413).

ACUTE MANAGEMENT OF FLARES

Disease flares, characterized by the acute onset of painful nodules or abscesses, are a hallmark of HS (Fig. 54-2). Medical therapy in HS is aimed at limiting the incidence of flares and reducing inflammation. However, patients continue to be susceptible to flares during medical treatment. Therefore, adequate management of flares is an essential part of the treatment strategy as the nodules and abscesses can be extremely painful and interfere heavily with daily life. Care must be taken to properly discriminate abscesses from inflammatory nodules in these situations as they require a different approach. Differentiation is based upon the fluctuating nature of a fluid collection (i.e., abscess) compared with the firm nature of an inflammatory nodule. Acute inflammatory nodules often benefit from intralesional corticosteroids that inhibit the synthesis of proinflammatory cytokines,¹⁵ whereas abscesses require incision and drainage to rapidly relieve symptoms of pain and pressure.^{16–18}



Figure 54-2. Acute HS lesion in the right axilla.

ANESTHESIA

Strict sterile technique is not required, and disinfection using chlorhexidine or alcohol is sufficient. Cryoanesthesia, for example, with liquid nitrogen or a refrigerating spray, is recommended as the inflamed area is difficult to

anesthetize using injectable anesthetics. Cryoanesthesia should be performed over the full length of the planned incision or injection site. The application of cryoanesthesia should be quickly followed by the injection or incision, as this technique results only in brief anesthesia (Fig. 54-3A and B). Alternatively, local anesthesia of an abscess can be performed with lidocaine with epinephrine through a 30-gauge needle.^{19,20} Alkalinizing the lidocaine by adding sodium bicarbonate solution may reduce the burning sensation during the injection caused by the acidity of lidocaine.²¹ Additional injections in a local field block pattern may be necessary for the patient's comfort.²⁰ Nonetheless, the procedure often remains painful, as the area is extremely difficult to anesthetize due to diffuse inflammation. Prior application of a eutectic mixture of local anesthetics (EMLA) containing lidocaine and prilocaine, for 30 minutes to 1 hour before the procedure may be used to reduce the pain of local injections or the incision and drainage procedure.

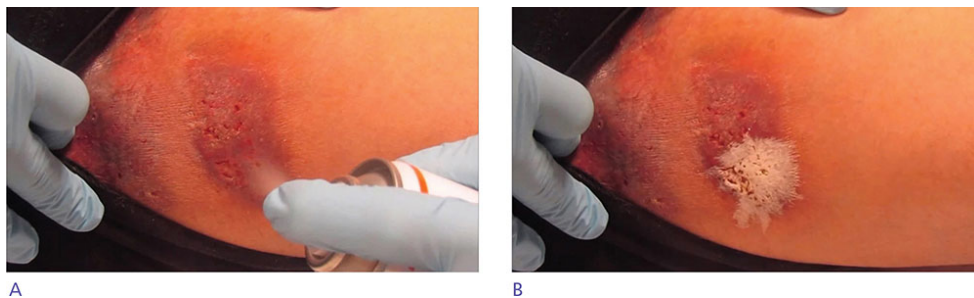


Figure 54-3. (A) Application of cryoanaesthesia to the medial left thigh before intralesional triamcinolone injection. (B) White coloring of the skin after application of cryoanesthesia.

TECHNIQUES

Intralesional corticosteroids

A solution of triamcinolone acetonide at a concentration of either 10 or 40 mg/mL can be mixed with 1% to 2% lidocaine with epinephrine in a ratio of 1:1.¹⁵ Depending on the size of the lesion, 1 mL of triamcinolone or 2 mL of the combined solution per nodule or plaque is sufficient. The solution is directly injected into the inflamed nodule, using a syringe with a 1-in 30-gauge needle. When a single nodule is difficult to identify amid an area of

inflamed, indurated tissue, the corticosteroid solution should be injected into the center of the indurated and erythematous area. If the diameter of the inflamed erythematous area spans more than 4 cm, the solution can be evenly distributed over two injection sites, infiltrating approximately 1 mL in each site.

Incision and drainage

The incision can be made using one of three techniques: cold steel, punch biopsy, or carbon dioxide laser. All incisions should be made parallel to the relaxed skin tension lines. An elongated triangular surgical blade (#11) or a blade with a small curved edge (#15) should be used for the cold steel incision.^{19,20} The stab incision should be made directly over the peak of the abscess, taking care not to puncture the back wall. When performing a CO₂ laser incision, the incision may be completed in the cutting mode or by vaporization in the ablative laser mode by repeated passing over the skin. Alternatively, the abscess can be opened with a 5- to 8-mm disposable biopsy punch to insure an aperture of sufficient size.¹⁷ The surrounding skin is stretched perpendicular to the skin tension lines so that the wound will form an oval.¹⁷ The biopsy punch is taken vertically down into the skin using a rotating motion until the abscess is reached. Subsequently, the abscess is allowed to drain spontaneously, pressure can be applied to the surrounding tissue to further drain the contents.^{19,20} The cavity is irrigated using a saline solution until the draining solution is clear. An additional injection with triamcinolone can be given in the surrounding infiltrated skin.

Postoperative management

Intralesional corticosteroid procedures do not require additional postoperative management. The incision site should be covered using gauze and absorbent dressing.²⁰ Dressings should be changed daily after irrigation of the wound. Adjuvant antibiotic therapy is not indicated. Patients should always be instructed to return if symptoms (redness, swelling, pain) persist, worsen or if systemic symptoms develop.²⁰

Results and recurrence rate

Intralesional corticosteroids

In a prospective case series with 36 HS patients, the use of intralesional triamcinolone acetonide 10 mg/mL resulted in significant reduction in physician-assessed erythema, edema, suppuration, and size of the lesion at a 7-day follow-up (Fig. 54-4A and B).¹⁵ In addition, a significant reduction in patient-reported pain visual analog scale (VAS) scores occurred after 1 day (VAS from 5.5 to 2.3). Results regarding the recurrence rate have not been reported.



Figure 54-4. (A) Inflammatory nodule in the pubic area before intralesional triamcinolone injection. (B) Result of triamcinolone injection after 7 days.

Incision and drainage

The results of incision and drainage are rapid but temporary in nature.^{16,17} One case series with six HS patients reported a recurrence rate of 100% after incision and drainage.²² Therefore, when abscesses recur at exactly the same site, excisional surgery for permanent eradication is indicated.²³

Complications

Intralesional injection of triamcinolone could potentially result in atrophic scar formation and hypopigmentation due to collagen and fat atrophy.

Systemic effects of soft-tissue corticosteroid injections rarely occur.²⁴ In incision and drainage procedures, puncture of the back wall of the abscess may lead to postoperative bleeding.²⁰

DEROOFING

Elective surgical procedures are indicated when medical treatment fails and HS lesions are persistent or recurrent at fixed locations. This is best done with the least possible destruction of normal tissue. The deroofing (also called unroofing) technique has emerged as one of the most effective methods of HS surgery.²⁵ The procedure was described for the first time in 1959 by Mullins et al.: “The multiple cavities containing pus and gelatinous material were adequately drained, and the lining was curetted thoroughly.”²⁶ The key element of the procedure is the complete exteriorization of the roof of the cavity, that is, abscess or sinus tract, leaving the (partly) epithelialized floor and walls exposed (Fig. 54-5).^{27,28} This lining is preserved, and the resection remains within the borders of the lesion. Excision of the area is only necessary if an epithelial lining cannot be recognized during the surgical procedure.

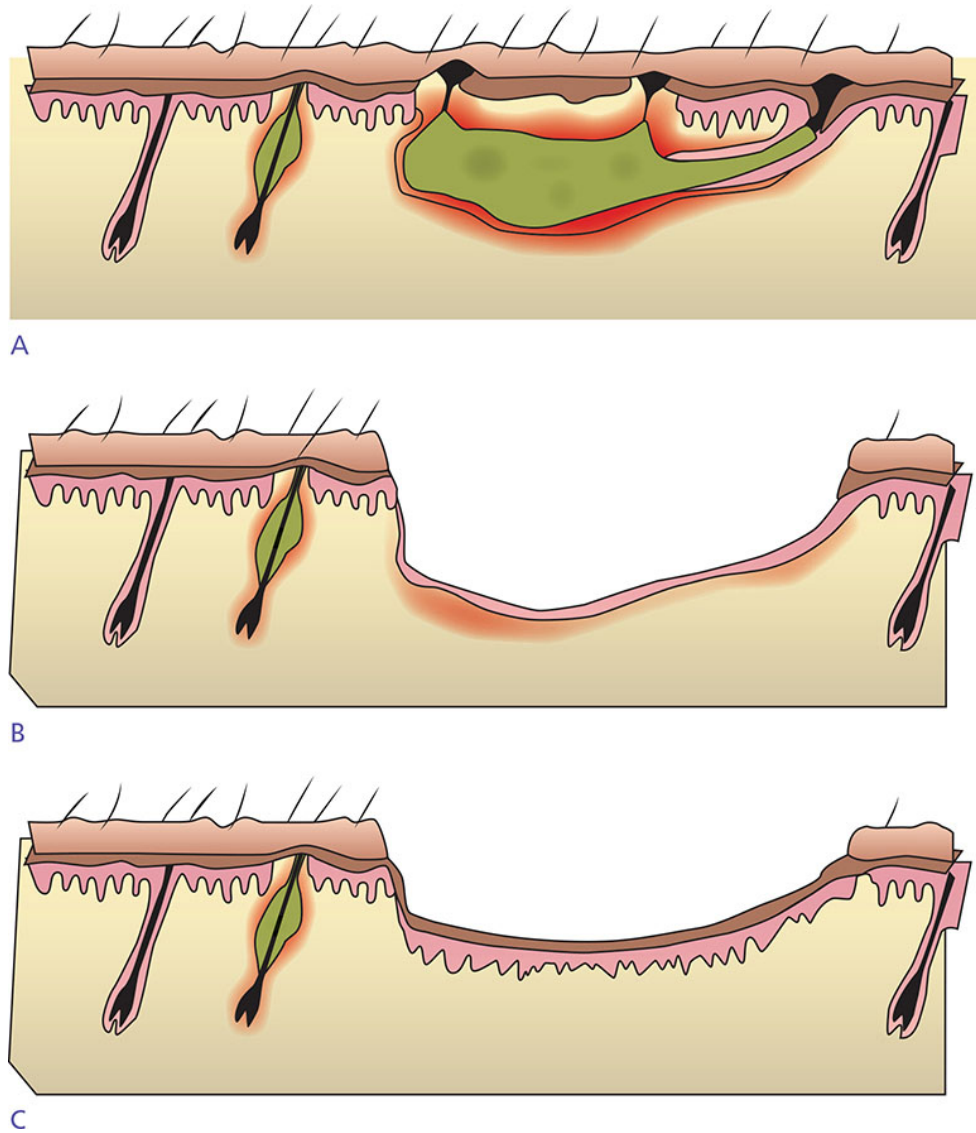


Figure 54-5. Schematic display of the deroofing procedure. (A) Sinuses with epithelialized floor containing pus and gelatinous material. (B) Deroofing procedure without damaging the epithelialized floor of the sinus tract. (C) Postoperative healing with regeneration of the epidermal layer.

Anesthesia

If the affected body surface area (BSA) is not larger than approximately 0.5%, deroofing is exceptionally suitable as an “office procedure” with use of local anesthesia.²⁹ Local anesthesia is usually performed in two steps.²⁵ First, an anesthetic containing lidocaine with epinephrine is injected to infiltrate the surrounding area. As previously described, adding sodium bicarbonate may reduce the burning sensation during injection.²¹

Additionally, the sinus tract can be injected with the same local anesthetic. Injecting the sinus with methylene blue can be used to assess the extent of the lesion(s). The procedure can be performed under procedural sedation and analgesia (PSA) or general anesthesia when preferred by the patient, or in cases of extensive inflammation or multiple lesions.

Technique

HS lesions selected for deroofing are identified by visual inspection and palpation, and can subsequently be marked with ink.²⁵ After visual inspection and palpation, a blunt probe is inserted in a sinus opening (Fig. 54-6A). When a probe is not available, the blunt tip of a closed, fine forceps or “mosquito” could be used. In case no openings are detected, a small incision is made to introduce the probe. An incision is made over or around the probe using an electrosurgical device in cutting mode or with a CO₂ laser. The cavity is subsequently examined with the probe in all directions to find and explore all possible communicating tracts. Sinus tracts can run for long distances dissecting and undermining the dermal layer of the skin. Care needs to be taken not to create false passages. The roof of the lesion must be completely exteriorized from each tract. The inflammatory granulation tissue, recognizable as a gelatinous mass, and reactive fibrosis trapped beneath the surface, must be surgically removed. Although the literature is inconsistent, removing the floor with a curette or electrocoagulation is not recommended.^{17,25,30} Any residual epithelialized sinus floor—if the surgeon is certain there is no active disease beneath it—is left in situ to assist healing by secondary intention (Fig. 54-6B). Primary closure needs to be avoided because remnant (active) foci of disease could be trapped underneath the skin, resulting in recurrence.

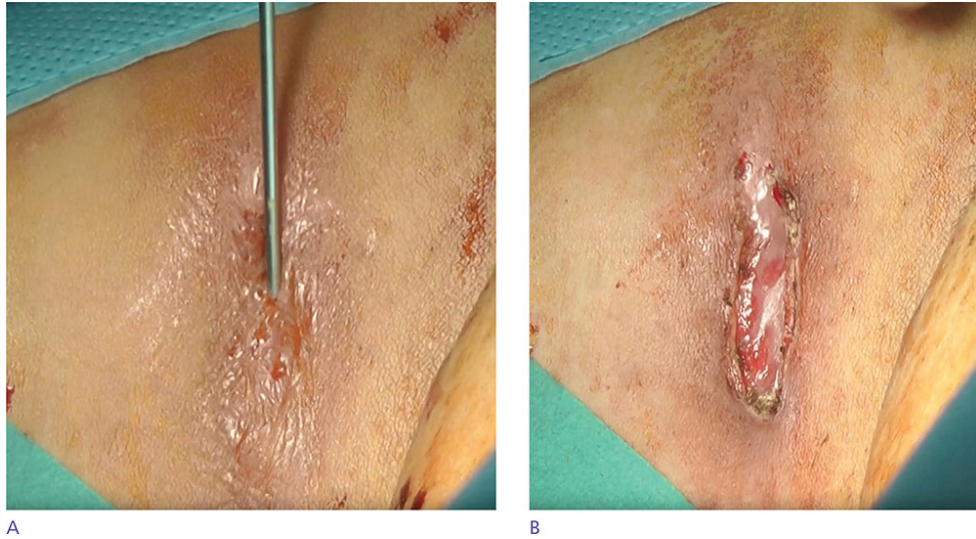


Figure 54-6. (A) Probe inserted in the draining HS lesion in the groin. (B) HS lesion showing epithelialized floor after deroofing procedure. (Used with permission from J. Boer, MD, PhD).

Postoperative management

Wound care consists of either povidone iodine ointment or an alginate dressing followed by paraffin gauze and absorbent dressing.^{17,25} Alternative topical agents include mupirocin and chlorhexidine. Subsequent application of paraffin gauze should cover the entire surface of the wound to avoid removing fresh epithelialization when changing dressings. Daily wound care involves gentle rinsing of the wound with saline or clear running water followed by the reapplication of the topical agent, paraffin gauze, and absorbent dressing. A follow-up visit may be scheduled between 7 and 14 days to evaluate wound healing.

Results and recurrence rate

There is currently no clear definition of a recurrence of HS after a surgical procedure. Therefore, systematic comparison of recurrence rates between studies is challenging. To date, only one prospective case series on electrosurgical deroofing has been performed.²⁵ This study included 44 patients and 88 treated lesions. After a median follow-up of 34 months, 83% (73/88) deroofed lesions did not show a recurrence. The deroofing procedure would be recommended by 90% of the patients.

Complications

Based on one study, the complication rates for electrosurgical deroofing are low. van der Zee et al. reported postoperative bleeding in 2% (1/44) of the treated patients.²⁵ No wound infections were observed, while the rates of paraesthesia and hypergranulation have not been described.

LIMITED EXCISION

The terms “limited excision” and “local excision” are used ambiguously throughout the literature.^{22,29,31–33} In this section “limited excision” is interpreted as the excision of an HS affected area, ~0.5 cm beyond the clinical borders of activity, within <1% of the total BSA.²⁹ Limited excision is indicated for fixed lesions or unepithelialized sinus tracts in a limited area.²⁹ This represents Hurley stage I and stage II lesions (Fig. 54-7A and B). Nodules are not suitable for deroofing as they do not have an epithelialized lining. Recurrent and persistent nodules, both inflammatory and noninflammatory, should be treated by excision. A deroofing procedure of a sinus (or abscess) may evolve into a limited excision when upon visual inspection the floor of the exteriorized lesion is not epithelialized.

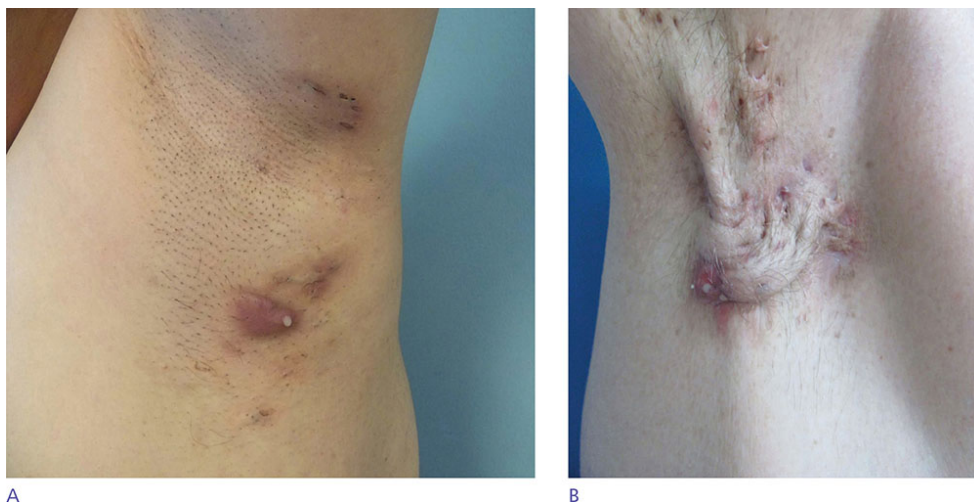


Figure 54-7. (A) Hurley I in the left axilla. (B) Hurley II of the right axilla.

Anesthesia

For limited excisions the choice between local, sedation (PSA), or general anesthesia is based on the size of the affected area as well as patient and surgeon preferences and the capabilities of the medical center. Due to the maximum dosage of lidocaine allowed, local anesthesia is feasible for lesions up to approximately 1% of BSA.²⁹ Local anesthesia can be performed as previously described using lidocaine with epinephrine.¹⁹ Infiltration should span an area large enough to incorporate the HS lesions with a 1-cm margin. However, anesthetizing an inflamed area is often difficult, and the procedure frequently remains painful under local anesthesia.

Techniques

Electrosurgery

The skin is disinfected using a chlorhexidine, povidone iodine, or 70% ethanol solution (which needs to evaporate completely before starting the procedure). First, the affected area is palpated thoroughly to estimate the extent of the excision. The anticipated area can then be outlined using a marker (incorporating a ~0.5-cm margin). The subsequent electrosurgical incision is performed using a blade or needle electrode tip at 35 W in cutting mode (major surgery setting). Dissection of the affected skin from the subcutaneous fat can be performed using the “cut” or “coagulation” mode. Performing the dissection in coagulation mode will result in less bleeding, but the tip may have more difficulty moving through the tissue. A practical tip is to keep the skin stretched under traction to facilitate dissection.³⁴ Subsequently, the edges are palpated and probed in search of additional sinus tracts. Once the area is clear of lesions and there is no further bleeding, the wounds are left open for secondary intention healing.

Carbon dioxide laser vaporization

A CO₂ laser with a wavelength of 10,600 nm is an effective alternative to electrosurgery in the treatment of HS.³⁵ This technique minimally affects the surrounding tissue and offers increased visualization of the operative site by partial hemostasis.^{17,36,37} First, if possible, a blunt probe is used to identify separate or interconnected tracts. The laser is used in continuous-wave mode at 20 to 30 W, generally with a spot size of 3 mm, to evaporate gradually top-

down both superficial and deeper lesions. Second, layers of the affected skin including the proliferative gelatinous mass are vaporized by repeated passes of the laser until healthy tissue is reached (Fig. 54-8A and B).^{36,37}



Figure 54-8. (A) Solitary nodule before CO₂ laser destruction. (B) Result directly after CO₂ laser destruction.

Postoperative management

Patients can be admitted to the hospital for observation overnight following limited excision under general anesthesia, or return home following a limited excision under local anesthesia. Wounds are preferably left open for secondary intention healing. Postoperative wound care is similar for both excision techniques and as described in the “deroofing” section. The use of vacuum-assisted closure is not required, as postoperative wounds are not chronic in nature. To evaluate wound healing, patients can be seen 7 to 14 days after surgery. A single topical application of silver nitrate or daily application of a topical corticosteroid (classes III to IV) can be used to treat possible hypergranulation.

Results and recurrence rate

To date, no comparative study between CO₂ laser and traditional (excisional) surgery has been performed. The appropriate surgical technique should be based upon operator experience and the individual needs of the patient.

Electrosurgery

A recent meta-analysis reported a pooled recurrence rate (five studies) of 22% (95% CI, 10—37%) after limited excision followed by different reconstructive techniques.³⁸ However, heterogeneity between these studies was very high ($I^2 = 85\%$) and average duration of follow-up was significantly correlated with recurrence rate. To date, no studies report on the satisfaction of medical and cosmetic effects of limited excision followed by secondary healing. One study reporting on limited excision with several different reconstructive techniques demonstrated that 90% (51/57) of the patients were willing to undergo further surgery if necessary.³¹

Carbon dioxide laser vaporization

Two prospective case series by Lapins et al. demonstrated recurrence within the borders of the treated areas after a mean follow-up of 27 to 35 months in 8% (2/24) and 12% (3/34) of the HS patients (all displaying Hurley stage II).^{36,37} Mikkelsen et al. interviewed 58 HS patients with a mean of 26 months after CO₂ vaporization. Recurrence of HS lesions was reported by 29% of the patients.³⁹ In general, patients who undergo CO₂ surgery report satisfactory scores for pain, scarring, and overall treatment satisfaction.³⁵ In addition, 91% (53/58) would recommend the CO₂ vaporization to other HS patients.

Complications

Electrosurgery

Postoperative complications after limited excision rarely occur. No studies specifically report the complications of limited excision followed by secondary healing. One study performed 363 operations closely related to a limited excision. The incidence of postoperative complications after

secondary intention wound healing was: hypergranulation 7.3%, infection 1.9%, bleeding 1.9%, paresthesia 1.0%, and contracture 0.6%.⁴⁰

Carbon dioxide laser vaporization

The complication rates after CO₂ vaporization are low. Lapins et al. did not report postoperative bleeding in 2 case series with a total of 58 patients,^{36,37} while Mikkelsen et al. described one (1/58; 2%) episode of patient-reported postoperative bleeding and one (1/58; 2%) contracture.³⁹

WIDE EXCISION

A “wide excision” is typically indicated in patients with Hurley III disease (Fig. 54-9). In this section the “wide excision” procedure is interpreted as the resection of the entire affected area, incorporating a ~1.0-cm margin (more extensive compared with the “limited excision”). The difference with a limited excision is based on the size of the affected area: a wide excision encompasses $\geq 1\%$ of the total BSA, whereas a limited excision is limited to Hurley I-II lesions ($< 1\%$ BSA). When patients with Hurley III disease are planned for surgery, special attention should be paid to preoperative medical management. Anti-inflammatory therapy, for example, TNF- α inhibitors and/or systemic antibiotics, is recommended to lower disease activity, which potentially might result in less extensive surgery.^{41,42}



Figure 54-9. Hurley III in the right axilla.

Anesthesia

Local anesthesia is not sufficient to perform a true wide excision; therefore general anesthesia is required. The additional use of tumescent anesthesia during general anesthesia could yield advantages. The tumescent anesthetic solution, often consisting of highly diluted lidocaine, epinephrine, and sodium bicarbonate, may reduce intraoperative bleeding and postoperative pain.^{43,44} A disadvantage of additional tumescent anesthesia is a theoretically higher chance of a postoperative bleeding once the epinephrine has been cleared. When used with general anesthesia, the concentration of lidocaine may be as low as 0.04% to 0.05%; epinephrine is used in a concentration of 1:1–2 million; and bicarbonate is added as 10 to 20 mL in 1,000 mL 0.9% NaCl.⁴³ Due to the expected larger systemic uptake of lidocaine as a result of the extensive inflammation in the affected area, the maximum total lidocaine dosage for adults is 500 mg. The solution is subdermally injected using a rotation pump, special tubing, and long needles, and allowed to infiltrate the entire area before initiating the procedure.⁴³

Techniques

Most of the steps in the wide excision procedure are similar to those of the limited excision. However, in contrast to a limited excision, electrosurgery is preferred over evaporation by CO₂ laser in these large areas ($\geq 1\%$ BSA). Injection of a 1% methylviolet or methylene blue solution into the sinus tracts may be considered to ease the localization of sinus tracts during the procedure.³⁴ The epidermis, its appendages, sinuses, and associated inflammation and scar tissue should be removed only until soft, normal-appearing subcutaneous fat remains, taking into account a surgical margin up to 1.0 cm. Wide excision does not require the destructive en bloc deep to the fascia technique used in managing malignancy.¹⁷ In addition, the affected area should be excised in multiple stages during the procedure. This will result in a better overview and allows for better localization of additional sinus tracts as the often profuse bleeding can be more easily contained. When the affected area is totally removed, the edges are carefully palpated and probed to check for additional sinus tracts or cavities (Fig. 54-10A and B).

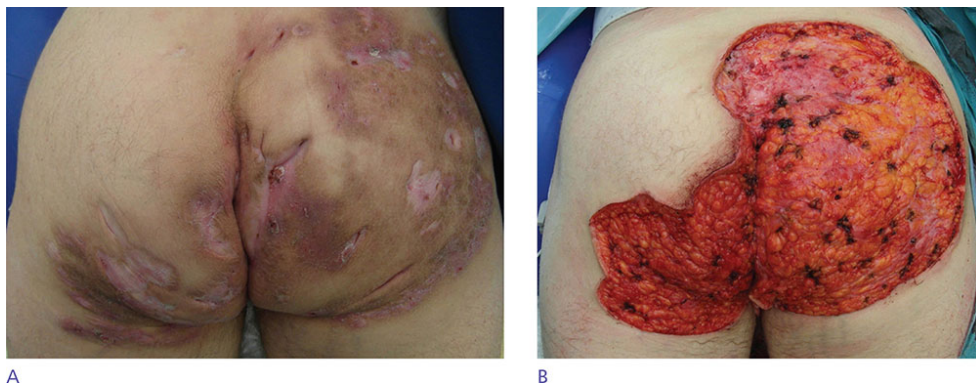


Figure 54-10. (A) Hurley III of the buttocks before wide excision. (B) Result directly after wide excision.

After removal of extensive HS lesions, there are multiple options for wound healing or reconstruction. Healing by secondary intention is preferred even for large defects, as minor residual foci of disease are allowed to migrate to the surface and may spontaneously heal. However, wound reconstruction may accelerate the healing of postsurgical skin defects and thus prevent the prolonged healing time associated with secondary intention healing. Several techniques have been described to close large defects after

wide excision.³⁸ Primary closure with flap reconstruction (e.g., local, rotation, or transposition) should best be avoided because the reintroduction of hair follicles in a site of HS predilection may result in recurrence within the flap (Fig. 54-11). For defects where shorter healing time is preferred, such as defects on the buttocks, an alternative closure technique is the use of autologous delayed split-thickness skin grafting (STSG) and platelet-rich plasma.⁴⁵ It is a relatively easy, inexpensive procedure which reduces postoperative morbidity and pain and may accelerate recovery after extensive HS surgery.



Figure 54-11. Recurrence in transposition flap in the left axilla.

Postoperative management

Patients are admitted for observation after the procedure. Special attention should be paid to the hemorrhagic status (i.e., assessment of serum hemoglobin levels) of patients with significant intraoperative blood loss and a medical history of anemia. Topical care for open wounds (either for healing by secondary intention or for delayed skin grafting) consists of either povidone iodine ointment or an alginate dressing followed by paraffin gauze and absorbent dressings.^{17,25} Depending on the amount exudate produced, wounds are rinsed once or twice daily with a saline solution or clear running water. Vacuum-assisted closure or hyperbaric oxygen therapy is not needed. Patients can be discharged from the hospital when postoperative pain management is adequate and medical home care is scheduled. From day one patients are instructed to stretch the wound area in order to prevent contractures of the newly generating scar tissue. Physical therapy and postoperative rehabilitation may be considered when patients develop contractures or are unable to perform the exercises without extra guidance. Patients should be seen 7 to 14 days after discharge from the hospital to evaluate the course of wound healing.

Results and recurrence rate

A recent meta-analysis analyzed three types of closures after wide local excision.³⁸ Recurrence rates were identified with four primary closure studies, seven skin flap studies, and eight skin graft studies. The average recurrence rates were as follows: primary closure, 15% (95% CI, 0–72%); skin flaps, 8% (95% CI, 2.0–16.0%); and skin grafts, 6% (95% CI, 0.0–24.0%). There was a high and statistically significant heterogeneity within the primary closure ($I^2 = 96\%$) and skin graft groups ($I^2 = 93\%$). Secondary intention healing after wide excision has not been sufficiently studied to draw conclusions. In general, lower rates of disease progression after wide resection, as well as a longer disease-free interval, may be achieved with the use of adjuvant biologic therapy.⁴⁶

Complications

The postoperative complication rate after wide excision was studied for the following closure techniques: primary closure, flap reconstruction, STSG, or healing by secondary intention.^{31,34,47} An overall complication rate of 17.8% was reported in a group of 106 patients with mixed reconstructive methods.³⁴ Most of the complications were minor, such as suture dehiscence (5.4%), postoperative bleeding/hematoma (5.0%), wound infection (3.7%), and contracture (1.7%).³⁴ Additionally, the incidence of complications over all reconstructive methods was studied by Bieniek et al. in 57 patients: pain (30%), wound infection (11%), contractures (7%), bleeding causing hypovolemia (5%), and excessive proliferation of granulation tissue (2%) were described.³¹ The (partial) loss of both flap reconstructions and skin grafts have been poorly studied. The complications and recurrence rates of wide excision followed by secondary intention healing have not been extensively studied. However, clinical experience suggests that the recurrence rate is lower than mentioned in the literature and complications of secondary intention healing are rare.

ADDITIONAL SURGICAL CONSIDERATIONS

Surgery is the cornerstone of HS treatment and may achieve local cure. However, the surgical treatment can be complex.

Preoperative assessment to identify nodules and sinus tracts is primarily done by inspection and palpation. However, the extent of the sinus tract formation can only be established during surgery, and the affected area is often considerably larger than expected based on the preoperative assessment. The addition of color Doppler ultrasound may add relevant information prior to surgery. Ultrasound examination, when performed by a skilled radiologist or dermatologist with experience in skin imaging, can give insight into the exact location, number, and size of the sinus tracts.⁴⁸ This may help to achieve a more anatomically oriented and precise excision.

Second, even though healing by secondary intention is the preferred method, some areas, specifically the buttocks, benefit from a shorter healing time. The suggested closure technique for this location is with an STSG (Fig. 54-12A, B, C). STSGs are traditionally taken from a donor site outside of the

affected area, often from the upper leg. As HS originates from the hair follicles and the epidermis is healthy, a thin STSG could also be harvested from the HS-affected area selected for excision. This reduces the burden on the patient as there is no donor site wound and cosmetically undesirable scar from the donor site. The STSG can be harvested using an electric or air-driven dermatome, set to cut at a thickness of 0.2 to 0.3 mm. After harvesting the STSG is meshed in a 1:1.5 ratio. Storing the STSG wrapped in a saline-moistened gauze in a refrigerator at 4°C allows for delayed grafting. Delayed grafting is necessary, as the depth of the excision in HS should reach the healthy subcutaneous fat which cannot sustain skin grafts. After approximately 14 days, the granulation tissue is developed properly and will support STSG. The use of platelet-rich plasma (PRP) increases the chance of survival of the STSG and forms a protective layer fixing the STSG in place without the use of glue or staples. First, half of the PRP should be applied to the granulating wound bed. The residual PRP should be applied on top of the STSG and activated by calcium- containing autologous serum, resulting in entrapment of the STSG in a thrombin-fibrin gel which ensures firm adherence to the wound bed.



A



B



C

Figure 54-12. Course of wound healing with the use of split-thickness skin grafts and platelet rich plasma. (A) Hurley III on buttocks before wide excision. (B) Delayed application of STSG 14 days after wide excision. (C) Result 48 days after surgery.

Last, photodynamic therapy (PDT) may be useful in the treatment of HS through selective, cytotoxic, and immunomodulatory effects.⁴⁹ Patients with long-standing HS sinus tracts unwilling or unable to undergo excisional surgery may benefit from a less invasive treatment with intralesional PDT. The procedure starts with administration of a local anesthetic, preferably using bupivacaine to prolong the anesthetic effect, followed by filling the sinus with a photosensitizing 5% 5-aminolaevulinic acid (5-ALA) gel using a plastic cannula.⁵⁰ During the incubation period of approximately 2 hours, the inlet/outlet needs to be covered in order to keep the photosensitizing solution within the cavity and in the dark. Subsequently the tip of an optical fiber at 630 nm is inserted in the opening until the end of the sinus tract is reached. Next, the cavity is irradiated by a laser in continuous mode at 1.2 W while slowly retracting the fiber.⁵⁰ A prospective case series treating HS patients with intralesional PDT demonstrated a 76% (29/38) complete response.⁵⁰ Best results are obtained in single or isolated sinuses. In patients with multiple, interconnected, or deep sinuses, two or more sessions are more frequently needed to achieve maximum response. Follow-up sessions can be performed at intervals of 5 to 7 weeks.

Patients with HS in the perianal or perineal area, especially male patients and those with concomitant intestinal bowel disease (IBD), are at risk of developing sinus tracts penetrating through the anal sphincter complex or communicating with the rectum (i.e., fistulas).⁵¹ Moreover, recent investigation showed that the prevalence of IBD in HS patients is four to eight times higher compared with the general population (3.3% vs. 0.41–0.74%).⁵¹ The presence of trans- or intersphincteric sinuses or fistulas should preferably be assessed by endorectal coil MRI preoperatively. Alternatively, a fistulogram could be performed. Patients with trans- or intersphincteric sinuses or fistulas should be operated on in collaboration with a gastrointestinal surgeon, who can insert a seton to mark the fistula or sinus tract.⁵²

Secondary intention healing is the preferred management for excisions in HS. Theoretically secondary intention healing may reduce the rate of recurrence by allowing the remaining aberrant keratinocytes or residual

keratin fibers to escape from the wound. Trapping these remnant foci of disease by primary closure or re-introduction of hair follicles in a site of HS predilection by flap reconstruction may induce recurrence in the operated area. However, to date there is no literature available to support this hypothesis.

CONCLUSIONS

Surgery is indicated throughout all stages of HS, with the exception of the mildest forms (Fig. 54-13). Acute surgical interventions, that is, intralesional injection of triamcinolone and incision and drainage, can be performed to quickly relieve symptoms of inflammatory nodules and tense abscesses. For these procedures cryoanesthesia is preferred. Local cure of HS can be accomplished with elective surgical procedures. Smaller areas can be treated with deroofing and/or limited excision, depending on the presence of epithelialized cavities. For affected areas of at least 1% (Hurley III) a wide excision is indicated. Healing by secondary intention is preferred over primary closure, as the latter could trap remnant (active) foci of disease underneath the skin, resulting in recurrence. Special attention should be paid to the possible presence of trans- or intersphincteric sinuses or fistulas in patients with perianal/perineal HS. To ensure the best patient outcomes, surgeons should select the appropriate surgical technique based upon operator experience and the individual needs of the patient.

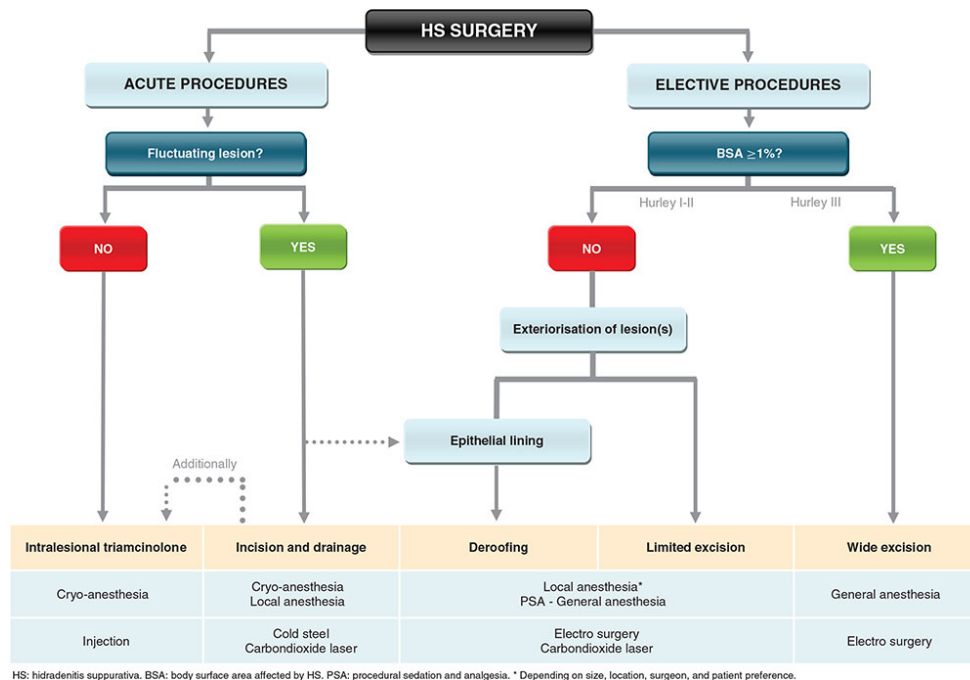


Figure 54-13. Schematic overview of surgical treatment algorithm.

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Part V

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CHAPTER 55 The Cosmetic Consultation

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SUMMARY

- The demand for cosmetic procedures, both invasive and noninvasive, is increasing dramatically.
- A thorough consultation is invaluable for patient education and comfort.
- Patients vary widely in their desires and expectations, and the consultation is the ideal time to tease out a patient's individual preferences.

Beginner Pearls



- The interaction with the front desk sets the stage for everything that follows.
- Etiquette for a physician's office staff must be similar to that seen in high-level hotels or retail stores.

Expert Pearls



- A cosmetic interest questionnaire that lists problems and procedures the patient wants to discuss helps to streamline the consultation.
- Use a variant of responsive listening—repeating back to the patient what he or she expressed to the nurse or assistant in the preliminary interview.

Don't Forget!



- The appearance of the reception area is particularly important when treating cosmetic patients.
- The public generally does not understand that surgery may be less expensive than the combination of nonsurgical procedures necessary to produce desirable results.

Pitfalls and Cautions



- Patient expectations must be set by the physician with both clinical and financial boundaries: the patient who expects to pay for one syringe of a filler but requires at least six syringes to attain the desired result will not be satisfied.
- Body dysmorphic disorder is the most common psychiatric condition seen in patients seeking cosmetic procedures.

Patient Education Points



- Be clear that nonsurgical procedures can provide excellent, but still not surgical, results.
- A physician must say “no” to any treatment they believe is medically or aesthetically inadvisable.

Billing Pearls



- Do not automatically write off procedure fees or offer reimbursement without checking with your malpractice carrier; returning money to a patient prior to discussion with your carrier could negate your insurance coverage if the incident is litigated.

CHAPTER 55 The Cosmetic Consultation

INTRODUCTION

The demand for cosmetic procedures, both invasive and noninvasive, is increasing. According to the 2016 Consumer Survey on Cosmetic Dermatologic Procedures conducted by the American Society for Dermatologic Surgery (ASDS), the percentage of people considering cosmetic treatment has increased from 30% in 2013 to almost 60% in 2016, with nearly 6 in 10 surveyed considering a cosmetic procedure.¹ The top factor influencing their decision to have a procedure was their dermatologist (53%). Thus, a successful consult is critical.^{2,3}

FIRST CONTACT

The first contact a prospective patient has with the office is the front desk, whether by phone, online, or in person. That interaction will set the stage for everything else that follows. Phone calls and emails must be answered promptly. Unfortunately, it is estimated that the volume of phone calls to doctors offices has increased up to 50% over the last decade as patients seek help managing approvals for prescriptions (which may be needed even for cosmetic procedures) and try to avoid doctor visits by soliciting information by telephone.⁴ As more offices set up electronic communication methods with patients, phone receptionists are pulled from the phone to their computer screens. It is therefore critical to balance telephone, online, and in-person demands.

Any employee hired for direct patient contact on the phone must be polite, professional, friendly, and have the ability to remain calm. Etiquette for physician's office staff must be similar to that seen in high-level hotels or retail stores (Table 55-1). Basic guidelines can be gleaned from business sources by studying the most successful customer service companies such as Ritz Carlton Hotels and Nordstrom Department Store.⁵

Table 55-1. Phone Etiquette

Basic Phone Etiquette When Scheduling the Cosmetic Consult	
1.	Never let the phone ring more than 3 times before picking up.
2.	When answering, speak clearly and smile. Smiling while on the phone helps keep your tone positive.
3.	Identify yourself and the office and ask for the name of the caller like: "Hello, Dr. Jones Dermatology. This is Jane. To whom am I speaking?"
4.	Repeat the caller's name and ask the reason for the call: "Hello Mrs. Smith. How may I help you today." Be sure to take notes with the patient's name and contact information while speaking in case the call is lost.
5.	If the call cannot be taken immediately, do not place the caller on hold before asking and receiving permission to do so. "Mrs. Smith, I apologize that I am on another line. May I put you on hold briefly?"
6.	If you know it will be a long wait on hold, instead offer to call the patient back. "Mrs. Smith, I don't want to keep you waiting. May I take your information and get back to you?" And return the call as promised.
7.	If the caller asks a question for which you don't know the answer, be honest. "Mrs. Smith, I apologize that I can't answer that question for you, but I will have our cosmetic coordinator return your call. She can explain everything." Or "I will ask the doctor as soon as she is between patients and get back to you."
8.	When transferring phone calls to other staff members, be sure to share the name of the patient so they too can start with "Mrs. Smith, this is Kathy, Dr. Jones' nurse. Jane said you had some questions for me before setting up your appointment."
9.	Always get the best number (and an alternate) and the best time to have a call returned to the caller, especially if a manager or another team member must return the call.
10.	Always thank the caller for his or her time and patience.
11.	When possible, let the caller hang up first and, if using a receiver, hang up the phone gently.

Staff speaking with potential patients must be knowledgeable regarding the services offered, the physician and other providers, and financial expectations. When new procedures are added, staff must be informed; it does not inspire patient confidence if the first staff person on the phone has never heard of the procedure. Do not assume that patients know the doctor's qualifications; credentialing the physician during that initial phone call can make the difference in whether the caller becomes a patient. Many offices do not quote procedure prices by phone. However, the incoming patient must be informed of consult cost, the scope of the visit, and whether there is a possibility of additional fees if procedures are performed on that day. Callers must have the opportunity to speak with someone in detail about upcoming procedures, especially if they may be performed on the date of the consult. Some practices cross-train all employees to have that discussion. At other times, staff responsibility is divided into clinical and nonclinical groups, and therefore excellent communication between them is critical.

THE OFFICE

When a new patient arrives at your office for a cosmetic consult, they should feel welcomed. This is akin to the difference between a maître d' who makes you catch his attention versus the one who catches yours. Similarly, the area for patient check-in at the office should be clearly marked and situated so the patient sees the receptionist's smiling face on initial entry. If the receptionist is not yet ready to take care of a patient, or if there will be a delay before seeing the physician, a smile, apology and the offer of a beverage or snack while waiting is generally appreciated. If the wait will be significant, staff should be instructed to call patients before they arrive; this conveys to the patient that the office values their time.

The appearance of the reception area is particularly important when treating cosmetic patients, as it is a reflection of the physician's aesthetic. At the most basic level, it should be clean and uncluttered with enough personal space for the patient to check in with a sense of privacy. A smooth and organized flow from reception to waiting room or rest room and then examination or procedure room adds to the new patient's foundation of trust for the office.

Office décor should reflect the physician's brand, location, and patient base. A beautiful cosmetic office in Arizona may have a southwestern theme with muted tones and stone, one in New Orleans, crystal and glass; and in New York, ultramodern spare white and oak. An office catering primarily to men might choose to include sports-themed memorabilia. Millennials may prefer a high tech environment. Walking into the office may also give a sense of the physician and can incorporate their hobbies or interests, whether by displaying photos of travel, Hollywood memorabilia, or midcentury furniture.

The color palate is also important. Studies in the fields of design, marketing, and branding have revealed strong connections between color and emotional and even physical reactions, an effect termed chromodynamics. Colors are considered cool or warm based on their respective association with water and sky (blues) or the sun (reds). Red, yellow, and orange are "high-arousal" colors, and may raise blood pressure. Blues, greens, and violets are "low-arousal" colors that tend to calm and relax. Particular colors are associated with psychological characteristics and traits such as red for both war and love, green for nature and healing, and blue with

stability and trust.⁶ Color combinations can trigger responses based on where the reflected light hits the retina. Color fatigue is a pulsating or vibrating effect caused by conflicting signals coming from the optic nerve when seeing adjacent bright complementary colors.⁶

New patients are often excited and anxious. The choice of color for your office entry, reception, and waiting areas can act in one of three ways: active, passive, or neutral. The stimulatory effect of a red waiting room would not be ideal. Pale yellow used as an accent may be soothing and make the occupant feel happy, but too much has been shown to make people more likely to feel frustrated and lose their temper. Blues may reduce blood pressure, though some pale blues may appear chilly or impersonal.⁷

Research has shown that the average time spent in any doctor's waiting room is 21 minutes.⁸ An uncomfortable space will make the wait seem longer. Chairs or couches should be easy to get in and out of without assistance and there should be surfaces on which to put a beverage. A cosmetic practice may make the patient feel more cared for by having a beverage or snack area. Information about procedures offered and products sold can be accessible but not cluttered. Depending on the patient population and personal preferences of the physician, offices may also provide up to date popular magazines, interesting coffee table books, computer monitors with educational information, or television monitors.⁹

THE CONSULT

Preparation

The past medical history and list of medications are as important for a cosmetic consult as for any medical visit.¹⁰ Whether patients fill out these forms online via a patient portal or in the office, the nurse or medical assistant must review details with the patient to make sure it is complete. The medication list must include both prescriptions and over the counter medications, vitamins, and supplements. Allergies and sensitivities must be noted where they will be visible on each visit. The physician must be aware of the patient's general health, and any procedure-specific minor or major risks associated with orals, past procedures, or underlying conditions.

Patients are generally unaware of the anticoagulant effect of fish oil and baby aspirin, but it can be significant when using injectables.¹¹ Patients with history of herpes simplex virus may require antiviral prophylaxis for facial or genital procedures. A predisposition to keloid formation is a relative contraindication to injecting poly-L-lactic acid and to some surgical procedures, or may require preplanning postprocedure interventions. Radiofrequency or ultrasound heating should not be used over an untreated hernia, and might also be problematic over surgical mesh from a herniorrhaphy. Staff must be aware of procedure-specific concerns and highlight them in the patient record.

Equally important is a detailed history of past cosmetic procedures. Patients frequently forget (or decline) to include cosmetic procedures in their surgical history. Rhinoplasty, even if done 30 years earlier, can have implications on vascular anatomy and, therefore, on safe filler injection. Seeing how a patient healed post rhytidectomy or abdominoplasty is informative. Staff must question patients about prior treatment with botulinum toxin, filling agents, lasers, other energy-based devices, suture or thread lifts, chemical peels, noninvasive fat reduction, and cosmetic surgery. In addition to eliciting approximate dates the procedures were done, questions should include product used, provider of the service or procedure, and patient satisfaction. Most patients do not know the exact filler or toxin injected, but if injection was done by a reputable physician, it is a reasonable assumption that it was FDA-approved and if needed, records can be obtained. The distinction is medically important when planning future treatment: injecting filler over some permanent fillers not available in the United States can ignite an inflammatory, nodular, or infectious reaction. Moreover, for those with excess or inappropriately placed filler, knowing if it is a hyaluronic acid gel determines whether hyaluronidase injection will be helpful. Finding out whether the patient was happy with the results—and why—helps the physician determine if realistic expectations can be achieved. The patient's current skincare regimen and experience with retinoids, hydroquinone, or other common ingredients also should be documented in order to maximize results and for postprocedure instructions.

A cosmetic interest questionnaire that lists problems and procedures the patient wants to discuss helps to streamline the consultation (Fig. 55-1). If appropriate, it allows the nurse, medical assistant, or cosmetic coordinator doing the initial patient interview to begin to review potential procedures

offered in the office. An associated question is “why now?” Is the cosmetic improvement being sought to prepare for an upcoming event like a wedding, to recover from a serious life event like a divorce or to feel better after an illness like cancer? This facilitates a smoother visit once the patient is brought in the room.

PATIENT NAME _____ DATE _____

Are there other conditions/services we provide that interest you? [YES] [NO].

If NO, end here IF YES, please CIRCLE all that apply:

I AM INTERESTED IN FINDING OUT MORE ABOUT TREATMENT OPTIONS FOR:

Skin discoloration	Facial lines, wrinkles	Facial sagging	Looking “old” and/or “tired”
Dull looking skin	Dark circles under eyes	Drooping brows or eyelids	Sagging skin body
Blotchy skin	Undereye “bags” or puffiness	Sunken cheeks and/or temples	Unwanted fat
Uneven skin tone	Frown lines between brows	Jowels, jaw drooping	Loss of contour abdomen, hips, thighs, buttocks
Large pores	Forehead lines	Turkey neck	Excessive sweating
Rough skin texture	Nasolabial folds or “parentheses”	Thin lips	Stretch marks
Skin discoloration	Lip lines	Unwanted “moles”	Acne scars
Age spots/brown spots	Marionette lines	Hands “look old”	Surgical or traumatic scars
Red spots/spider veins	Nose shape	Unwanted hair	Keloid scars
Face and/or neck redness	Neck and/or chest lines/wrinkles	Leg veins	Unwanted tattoos

I AM INTERESTED IN FINDING OUT MORE ABOUT THE FOLLOWING TREATMENT(S):

Skin products/skin regimen	Botox, Dysport, Xeomin for lines and wrinkles	Fraxel laser for photoaging (wrinkles, discoloration)
VBeam lasers for red spots and spider vessels	Fine line or wrinkle treatment with fillers	Fraxel laser for scars or stretch marks
QsNd:YAG lasers for brown spots	Facial contour restoration with fillers	Thermage tissue tightening
IPL (photofacial) for red and brown spots	Lower lid tear trough correction with fillers	Coolsculpting or Kybella noninvasive fat reduction
Clear & brilliant for pores, fine lines, dull skin	Lip restoration with fillers	Sclerotherapy for leg veins
Microdermabrasion or chemical peels	Laser hair removal	Cosmetic mole removal

WHEN LOOKING AT MYSELF IN THE MIRROR, COMPARED TO MY TRUE AGE, I BELIEVE I LOOK:

Younger than my age	-----	My age	-----	Older than my age
1	2	3	4	5

Figure 55-1. The cosmetic questionnaire.

After review of the medical and cosmetic history and patient's cosmetic interests, the patient should be prepared for the physician. That may include the patient removing facial makeup, pulling hair away from the face, or changing into an examination gown. Some offices take photos at this time, while others wait until immediately preprocedure. These preparations save time for the physician who can now focus on the patient.

Evaluation

A successful consult—one that converts an interested consumer into a patient—rests on the rapport between the physician and patient. Before entering the examination room, physician and staff should put cell phones on silent to minimize distraction. If the physician knows she will be interrupted for an expected phone call, explain, and apologize to the patient in advance. Even if there is only one physician in the office, the physician should introduce herself to the patient on entering. Older studies suggested patients prefer to be called by their last name, but this may have changed, along with the transformation of “doctor” and “patient” to “health care provider,” and “consumer,” respectively.¹² A safe standard is to refer to the patient by last name until he or she says otherwise. Alternatively, match the way the patient refers to the physician—if the patient uses a first name, the physician certainly can. Taking the time to sit down during the consultation rather than standing has been shown to have a positive effect on the doctor-patient relationship.¹³

The single most important factor in establishing a good relationship with the patient is to listen. Despite, the inclination to get the answers via rapid fire questions, speak slowly, use open-ended questions, and let the patient speak. If time is of the essence, use a variant of responsive listening—repeating back to the patient what he or she expressed to the nurse or assistant in the preliminary interview as in “My nurse Tina and I reviewed your conversation. My understanding is that you are most concerned about your jowls.” This defines the physician's assistants as part of the team and let the patient know that the team has heard their concerns.¹⁴ After reviewing the history, hand the patient a hand mirror and ask for him or her to point out major concerns. This keeps the focus on what the concern is, rather than on

one specific treatment option about which that the patient may have heard.^{10,15}

After reviewing the pertinent history and establishing the patient's concerns, it is time for the physician evaluation. For most noninvasive cosmetic dermatology procedures, it is best to examine the patient sitting upright or standing in order to see the effect of gravity. Look at the patient from multiple angles and gently palpate, pull, and pinch tissue as needed and ask the patient to make expressions. Include additional physician examination as appropriate for the specific procedures being considered. Document pertinent negatives such as the absence of thyromegaly or umbilical hernia during a consult for submental or abdominal fat reduction, respectively.

Recommendations

The physician's recommendations should be based on the patient's physical, social, and economic concerns. Sometimes the answer is straightforward, such as treating facial telangiectasias with a series of vascular laser or intense pulsed-light treatments. More often, achieving the requested results noninvasively will require a combination of procedures to volumize, relax, resurface, tighten, or lift. If you think referral for surgery is appropriate, find out if it is a consideration, and if not, why not. Be clear that nonsurgical procedures can provide excellent, but still not surgical, results. The public generally does not understand that surgery may be less expensive than the combination of nonsurgical procedures necessary to produce results. Patient expectations must be set by the physician with both clinical and financial boundaries. A patient who expects to pay for one syringe of a filler but requires at least six syringes to get to the desired result will not be satisfied.

Today, most patients arrive for consultation after having already researched procedures on individual physician, specialty, academy, industry, informational, and community websites. While educational, these sites also provide opinion boards for dissatisfied patients. The physician bears the burden not only of explaining their own recommendations, but of dispelling common myths. Be prepared to explain what you expect the procedure will achieve for that particular patient, how it is performed, the number of times it must be performed and at what interval, the expected degree of discomfort, downtime and posttreatment care expected, and risks involved. If multiple

procedures are being considered, explain why one is recommended or why the patient might prefer one over the other. If there are multiple procedures, design a reasonable plan that balances the patient's priorities with what you as the expert think will make the most significant improvement in appearance within the patient's health, time, and budget constraints. And be prepared if asked to let the patient know how many of each of those procedures you have done—is it your bread and butter everyday type, or is it something new that you have just started but in which you feel quite comfortable—and why?¹⁶ Finally, be clear that every procedure has benefits and risks and that there are no guarantees of outcome.

The time required for adequate explanation may be more than the physician has available during a busy schedule. Engaging assistants who regularly work with you and know your thought process begin the consultation during their preliminary patient interview provides a frame of reference for understanding. When in the room with the patient, be present, face the patient, and show that you are actively listening and remembering.¹⁴ The physician and staff should use similar language that is easily understandable to a layperson and provides a consistent message. Use of visual paper or digital educational resources developed by the doctor, specialty association, and/or industry, may be helpful. After the physician provides specific recommendations, they can leave the room (without appearing to rush out) in order for the staff to review the details.

THE DIFFICULT PATIENT

Most successful aesthetic physicians gain personal and job satisfaction from knowing they have many appreciative, long-time patients who refer family and friends, thereby increasing the circle of happiness. However, patients, like doctors, are as diverse as the world population. Especially in the field of aesthetics, personality, appearance, communication skills, and appearance can attract or repel a prospective patient regardless of clinical skills. Thus, no physician is going to be the perfect fit for everyone. Conversely, there are times when the patient is not the perfect fit for the physician. A physician must say “no” to any treatment they believe is medically or aesthetically inadvisable. The physician will be held responsible for any complication,

and a bad aesthetic result—even if it is what the patient wants—is the worst advertisement for your practice.

During the consultation, the physician and staff can screen patients by noting the patient’s verbal and nonverbal cues. These may suggest the patient won’t be satisfied with the physician, office, or procedure. There are also patients who must be approached carefully because of mental illness. One study found that up to 47.7% of patients seeking cosmetic surgery in a Japanese plastic surgery center met the criteria for a mental disorder between 1980 and 1997.¹⁷ Not all mental disease is a contraindication for cosmetic procedures, and there are many patients without diagnosable mental illness who should be treated only with extreme caution. What follows are four common categories of “difficult” patients seen in aesthetic practice, and guidelines for how to manage them.

Body Dysmorphic Patients

Body dysmorphic disorder (BDD) is the most common psychiatric condition seen in patients seeking cosmetic procedures.¹² The Diagnostic and Statistical Manual of Mental Disorders 5 (DSM-5) defines BDD as “distress due to a perceived physical anomaly.”¹⁸ In a literature review, it was estimated that 6% to 15% of patients presenting for treatment in a surgical dermatology practice suffer from body dysmorphia.¹⁹ Another article noted that BDD occurs in 2.4% of the U.S. population and makes up 2% to 7% of patients in cosmetic surgery practices and 9% to 15% in dermatology practices.²⁰ Although cosmetic practices generally see more female than male patients, body dysmorphia is equally common in both men and women in outpatient mental health settings.^{19,20} Any area of the body may be the focus of concern, though the most common BDD complaints involve the skin (such as scarring), hair, and nose.²⁰ Because these patient concerns are “perceived” rather than real, it is not surprising that few patients are satisfied with any treatment: one study reported 75% of body dysmorphic patients being dissatisfied with their results.²¹

The easiest way to screen for BDD during the consultation is to have the patient point out concerns while looking in a mirror. Confirm that you see what the patient sees. Unfortunately, some patients have a more subtle presentation of BDD. The issue may not become apparent until follow-up to

a procedure while reviewing before and after photos. Whenever it becomes clear that a patient is not able to see what the physician and staff see, it is time to discontinue additional treatment. Tell the patient that unfortunately you are not seeing what she sees and, as such, you are unable to change it. Suggest that another aesthetic physician may serve her better. An official discharge from the practice is usually not necessary, just your empathetic acknowledgment that you wish you could help but you cannot, though check with your malpractice carrier regarding the advisability of discharging the patient from the practice.²⁰

The Overly Anxious Patient

The overly anxious patient is generally benign, but may be the most time consuming and emotionally draining type of patient. This patient repeats the same questions before every decision, despite similar repeated detailed answers given by the physician and staff. Some excessively anxious patients just require reassurance. However, informed consent requires that the patient has had all of her questions answered. Determining whether the patient wants the physician to make the decision for her or whether she is not ready for the procedure can sometimes be difficult. If unsure, suggest that the patient return another day after thinking about it further. Both physician and staff should be prepared for frequent calls before and after any procedures. Most important, despite the frustration of having to repeat the same information, everyone must treat the patient with kindness and seriousness.²²

The Hagglers Patient

The increased competition for patient dollars has given rise to the commoditization of aesthetic procedures. Advertised specials by “syringe” or “cycle” and bundled procedure deals promoted through online sites give rise to “doctor shoppers,” patients who choose an office based on the price rather than the physician. Although there are certainly patients who initially find a physician through a discount and remain because of the results, most doctor shoppers switch providers based on the latest deal. Since they usually insist on getting prices before coming in for a consult, refusing to publish your procedure prices is an effective screening tool.

The more difficult are the patients who routinely “haggle” over price. While physician offices can set their own prices for services not covered by third-party payors, and certainly can give a discount or free services, ethics and practicality require reasonably standardized pricing. Some people feel entitled to “a deal,” while others complain that they cannot afford the doctor’s prices and should receive a discount. To those patients, say with kindness that you understand that cosmetic procedures are a luxury item and your staff will be happy to help figure out if there is a plan that fits their budget. Other patients do not value the physician’s time. Explain that the cost is based on the physician’s years of training and experience, as well as the cost of product that is used. The patient who values the physician, staff, and office will generally understand at this point.^{23,24}

The Angry Patient

This category of patients is generally the most difficult. Anger due to an understandable reason, such as a clerical error or the physician running significantly late, must be respected in order to salvage the doctor–patient relationship. The physician and/or involved staff should apologize and reassure the patient that the office considers the patient their priority and will address those concerns. A token gift like a cosmeceutical may drive home the physician’s sincerity.

Unfortunately, the patient who is irrationally angry is harder to manage. This patient wants to create a scene and may become abusive to the office staff even before seeing the physician. In this case, the first priority is to move the patient calmly and smoothly from the public to a private area like an examination room, office manager’s office, or even the staff break room if no other room is available.²⁴ Ideally, if a procedure has already been done, staff should take photos to document results. As quickly as possible, the physician accompanied by a staff member should be with the patient and listen. The patient must have the opportunity to vent without interruption. Instead of becoming defensive, the physician should practice responsive listening. A technique of summarizing what was said by the other person, responsive listening shows that person you were listening and confirms to both parties that you understand. Striking a balance of calm strength and empathy without condescension is not easy when listening to someone

degrade you and your office. Do not take it personally. And be very careful with your apology: remember that saying you are sorry that your office wasn't able to make the patient happy may help diffuse the situation without being a legal admission of guilt. It may be easiest to write off your consult fee in this situation. Do not automatically write off procedure fees or offer reimbursement without checking with your malpractice carrier. Returning money to a patient prior to discussion with your carrier can negate your insurance coverage if the incident turns into a legal case. Finally, be sure the patient is led out of the office expeditiously. If it would be helpful to document further clinical results, suggest the patient return before or after normal patient office hours. If it is necessary to discharge the patient from your practice, your carrier should be able to provide you with a template letter that includes the reason, referral information to a local medical society (so the patient can find another physician), and a records release form. Depending on your state, you will likely need to offer to see the patient for follow-up or emergencies related to any procedure done for a reasonable period of time (usually 30 days).^{25,26}

CONCLUSIONS

A successful encounter between physician and patient involves the interplay of various factors beyond procedural recommendations. The office setting, staff communication skills, and perceived attention from the physician combine to create a successful cosmetic consult that launches a long-term physician–patient relationship.

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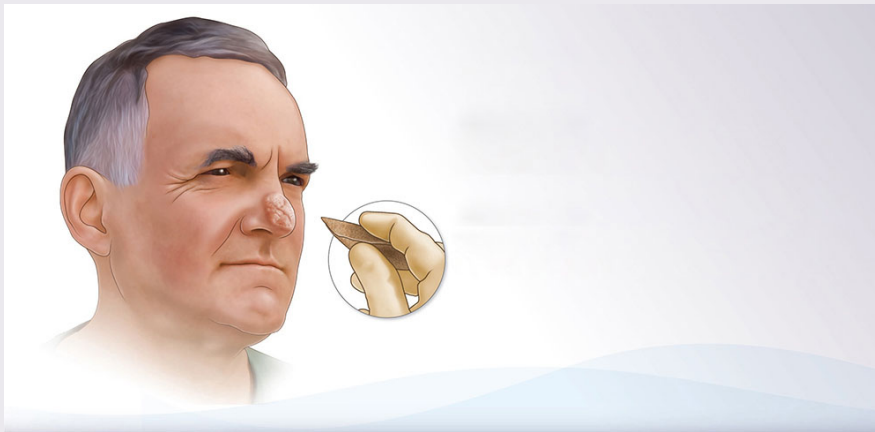
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CHAPTER 56 Dermabrasion

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SUMMARY

- Dermabrasion resurfaces skin, improving texture and contour irregularity.
- Manual dermabrasion is performed using sandpaper, drywall sanding screen, or a cautery scratch pad, and is a useful technique for treating smaller areas.
- Electroabrasion may provide similar outcomes to manual dermabrasion for discrete areas, possibly with less risk of milia formation.

Beginner Tips



- Manual dermabrasion requires only minimal instrumentation, while electroabrasion utilizes electrosurgical devices generally found in any dermatologic surgeon's office.
- Regardless of technique, dermabrasion should be continued to the depth of the papillary-reticular dermis interface.

Expert Tips



- Traditional mechanical dermabrasion is useful for treating larger areas.
- Manual dermabrasion or electroabrasion should be performed 6 to 8 weeks postoperatively for scar revision.

Don't Forget!



- Personal protective devices are of vital importance, particularly when performing traditional dermabrasion, as a significant amount of blood and body fluids may become aerosolized.
- Continuing dermabrasion to a level deeper than the papillary-reticular dermis interface increases the risk of scarring.

Pitfalls and Cautions



- Dermabrasion is relatively contraindicated for patients currently using isotretinoin or those that have used isotretinoin within 6 to 12 months.
- Infection postprocedure may lead to significant scarring; preoperative history taking and diligent postoperative monitoring or education are very important.

Patient Education Points

- Patients should be highly motivated to care for their wounds in the postoperative period.
- It is important to educate patients regarding the immediate postoperative appearance of a dermabraded area and regarding the importance of diligent wound care and sun protection.

Billing Pearls



- Dermabrasion should be coded with the 15780 series codes, and dermabrasion for purely cosmetic reasons is generally not covered by insurance.
- Since postoperative dermabrasion is usually performed 6 to 8 weeks postsurgery, it cannot be billed for in the case of flaps and grafts as they have 90-day global periods.

CHAPTER 56 Dermabrasion

INTRODUCTION

Dermabrasion is a technique designed to resurface skin by improving texture and contour irregularity. Traditional dermabrasion involves the use of a handheld motor-driven rotary device, mounted with a diamond fraise, wire brush, or serrated wheel.¹ A topical refrigerant may be used for anesthesia and to make the skin surface rigid for mechanical abrasion.² Typically, the level of abrasion is to the level of the papillary or superficial reticular dermis.³ Dermabrasion has been used to treat a wide variety of skin conditions, ranging from spot treatment of postoperative scars to full facial rejuvenation.⁴ Manual dermabrasion is performed using sandpaper, drywall sanding screen, or a cautery scratch pad, and is a useful technique for treating smaller areas.⁵ Different grades of sandpaper can be used to achieve multiple depths of ablation.⁶ Electroabrasion utilizes an electrosurgical device to ablate the skin with the added advantage of hemostasis intraoperatively, and is most suited for treatment of a focused skin area.⁷ In electroabrasion, machine power settings and distance between electrode tip and treated tissue can be adjusted to provide varying depths of tissue destruction.⁸

HISTORY

Dermabrasion

Kromayer first described the use of a motor-driven circular knives for skin resurfacing in 1905.⁹ Despite this, there was little interest in the field until

the 1950s.¹⁰ Kromayer later described the use of rotating burrs powered by a dental drill for the treatment of smallpox scars, warts, and pigmented lesions.¹¹ In 1935, Janson used a stiff bristled brush to treat tattoos, reporting good cosmetic results.¹² Credit is given to Kurtin for establishing and defining the technique of modern dermabrasion in 1953.¹³ He reported the use of ethyl chloride as an anesthetic and skin hardener, which permitted controlled dermabrasion in a relatively bloodless field. He also expanded the indications of dermabrasion to including lentigines, seborrheic keratoses, fine rhytides, and acne scarring. Since then, multiple contributions have been made by Burks,¹⁴ Orentreich,¹⁵ Hanke,² Yarborough,¹⁶ Mandy,¹⁷ Harmon,³ Roenigk,¹⁸ and Gold¹ to advance the field of dermabrasion.

Manual Dermabrasion and Electroabrasion

In 1947, Iverson reported on his use of carpenter's sandpaper, wrapped around a roll of gauze, to remove traumatic tattoos from the faces of patients.¹⁹ Now known as manual dermabrasion, this technique was adapted by McEvitt in 1948 to treat acne scarring.²⁰ However, this method of dermabrasion was complicated by the need for general anesthesia and the development of foreign-body silica granulomas. Later, full-face dermabrasion with rotary devices gained traction in the 1950s with Kurtin's influence, and with the development of ablative and nonablative lasers for resurfacing in the 1980s and 1990s, dermabrasion became less popular for skin rejuvenation. In this setting, manual dermabrasion found renewed interest as spot treatment for postoperative scarring. Zisser et al. found manual dermabrasion to be superior to traditional dermabrasion, as it obviated the need for a motor-driven device and use of skin refrigerants.⁵

Electroabrasion, or electrosurgical resurfacing, was described in 1999 by Burns et al., who used the technique to resurface scars resulting from Mohs surgery.⁷ Similar to manual dermabrasion, this technique was best suited for resurfacing of a smaller, focused treatment area. Campbell et al. further popularized the technique of electroabrasion by utilizing a hyfrecator, a device already present in most dermatology practices.⁸

APPROACHES TO DERMABRASION

Dermabrasion

Kurtin presented the first large case series of patients demonstrating the efficacy of dermabrasion in 1955 with his cohort of 273 patients, some followed for up to 4 years after treatment.¹³ Despite the lack of a control group, his paper generated significant interest in the field of dermabrasion.

In 1987, Robinson studied the use of dermabrasion on a series of 192 full-thickness skin grafts to the nose, periorbital area, and ear.²¹ Half the group was randomized to receive dermabrasion at 18 months following surgery, while the control group used sun protection and topical lubricants only. Photographs were taken at 6, 18, and 24 months after grafting and judged by the investigator after 5 years. Robinson found that grafts with elevated rims appeared to respond best to dermabrasion, whereas depressed grafts and hypertrophic scars in areas of full-thickness loss of skin and adnexal structures performed poorly. However, the scars in the dermabrasion group were no better than those in the control group.

Yarborough investigated the optimal time interval for dermabrasion treatment following wound injury.¹⁶ He abraded 97 facial scars 4 to 8 weeks following injury and 64 mature scars of 3 months to 13 years' duration. He found 89% of scars abraded at 4 to 8 weeks showed no visible scarring at 6 months, while all scars in the mature scar group were all still apparent, even if modestly improved.

Dermabrasion Step-by-Step

1. Ensure that all preoperative preparation is complete (e.g., photograph, consent). Administer antibiotic and/or antiviral prophylaxis as indicated prior to procedure.
2. Administer preoperative anxiolytics as needed.
3. Clean the treatment area with an antiseptic of choice (e.g., alcohol, chlorhexidine, betadine).
4. Provide necessary anesthesia with local anesthetic, tumescent anesthesia, or nerve blocks, as needed.

5. Paint the surface of treatment area with gentian violet, if desired.
6. Apply cryogenic spray/Frigiderm refrigerant to freeze the skin for approximately 10 seconds to provide a firm surface for dermabrasion. Only freeze the area that will be immediately dermabraded. Avoid refreezing and reabrading an area as much as possible.
7. Abrade the skin by pulling (instead of pushing) the body of the hand engine perpendicular to the direction of the end piece in arciform strokes.
8. Continue until punctate bleeding is visualized. This is the level of the papillary–reticular dermal junction. A fine, shredded appearance in the texture of the wound indicates the superficial portion of the reticular dermis. More superficial resurfacing results in a more limited degree of improvement, while deeper dermabrasion risks increased scarring due to adnexal structures being removed.
9. An assistant should help keep the skin taut and blot as needed with cotton towels. Gauze should be avoided as it can be entangled in the dermabrasion end piece.
10. Proceed from inferior to superior, as blood from a previously abraded area will flow in a gravitational direction away from the next area to be abraded. It can also be helpful to follow cosmetic subunits. Apply Vaseline ointment along the hairline to prevent entanglement of hair into the dermabrasion device.
11. After the treatment area is fully abraded, feather the periphery to create a more natural appearing transition zone.
12. Compress with a lidocaine with epinephrine soaked gauze for 5 to 10 minutes to obtain hemostasis and reduce stinging from the procedure.
13. Apply petrolatum ointment and hydrogel semiocclusive dressing to abraded sites to prevent crust formation until the epidermis is fully reepithelialized. This dressing should be changed every 3 to 5 days.
14. For larger procedures, consider systemic steroids (intramuscular triamcinolone or a short course of oral steroids) to reduce postoperative swelling.
15. Patients should be instructed to take acetaminophen and ibuprofen as needed for pain.

16. Reepithelialization should take 7 to 10 days, after which make-up can be applied. Patients should be instructed on strict sun avoidance, and may be started on retinoic acid and hydroquinone 3 weeks following the procedure.

Katz and Oca further refined Yarborough's findings in 1990.²² A split scar model was used to evaluate linear surgical scars following full-thickness excisions on the face, trunk, and extremities. The top half of each scar was treated with dermabrasion at 4, 6, or 8 weeks and the bottom half was left as a control. Katz found that although scars were improved when treated 4 or 6 weeks after injury, a greater number responded to abrasion at 8 weeks. This established the standard for time to dermabrasion at 6 to 8 weeks.

In 1995, Harmon et al. sought to delineate the cellular and structural mechanisms by which dermabrasion worked.³ They observed that dermabrasion of facial scars 4 to 8 weeks after injury increased collagen bundle formation and upregulated tenascin and $\alpha 6 \beta 4$ integrin expression, components vital in epithelial cell-cell interaction, and thus important for reorganization of connective tissue.

In addition to studying the direct efficacy of dermabrasion, several groups have investigated technical factors that may affect the quality of dermabrasion. Hanke et al. performed a laboratory evaluation of skin refrigerants and found a mixture of 35% Freon 114 and 25% ethyl chloride to be ideal, whereas pure Freon 12 preparations were too cold to be safely placed on the skin.² Rubenstein et al. described the development of atypical keloids following dermabrasion of patients taking isotretinoin. In their case series, one patient had been off isotretinoin for 6 months prior to dermabrasion yet still developed keloids on the cheek that did not completely resolve.²³ Though anecdotal, the recommendation to wait at least 6 to 12 months following isotretinoin for any dermabrasion procedure was therefore proposed.

Manual Dermabrasion Step-by-Step

1. Ensure that all preoperative preparation is complete (e.g., photograph, consent).
2. Administer preoperative anxiolytics as needed. For limited treatment sites in areas typically unaffected by herpetic or impetigo outbreaks, prophylaxis is generally not necessary.
3. Clean treatment area with antiseptic of choice (e.g., alcohol, chlorhexidine, betadine).
4. Provide necessary anesthesia with local anesthetic.
5. Abrade the skin with sterile (or autoclaved) 200-grit waterproof sandpaper (e.g., Canada Sandpapers Ltd.), drywall/plaster sanding screening (3M Corp, St. Paul, MN), or electrocautery scratch pad (Valleylab, Boulder, CO). The sandpaper can be wrapped around the barrel of a syringe or folded in three around the surgeon's index finger. A gentle back-and-forth or circular motion should be used.
6. Continue until punctate bleeding is visualized. This is the level of the papillary–reticular dermal junction. More superficial resurfacing results in a more limited degree of improvement, while deeper dermabrasion risks increased scarring due to adnexal structures being removed.
7. An assistant should help keep the skin taut and blot as needed.
8. Proceed from inferior to superior, as blood from a previously abraded area will flow in a gravitational direction away from the next area to be abraded. It can also be helpful to follow cosmetic subunits.
9. After the treatment area is fully abraded, feather the periphery to create a more natural appearing transition zone. Smooth the entire area with 400-grit sandpaper.
10. Compress with a 1% lidocaine with epinephrine soaked gauze for 5 to 10 minutes to obtain hemostasis and reduce stinging from the procedure.
11. Apply Vaseline ointment and hydrogel semioclusive dressing to abraded sites to prevent crust formation until the epidermis is fully reepithelialized. This dressing should be changed every 3 to 5 days.
12. Patients should be instructed to take acetaminophen and ibuprofen as needed for pain.

13. Reepithelialization should take 7 to 10 days, after which make-up can be applied. Patients should be instructed on strict sun avoidance and can be started on retinoic acid and hydroquinone 3 weeks following the procedure.

Manual Dermabrasion

Although Iverson and McEvitt pioneered manual dermabrasion in the 1940s, the first randomized control trial evaluating this technique was conducted by Poulos et al. in 2002.²⁴ Fifteen patients with scars following full-thickness skin excisions were assessed with a split scar model. Dermasanding was performed at 6 to 8 weeks to a randomized half of the scar using 200-grade sandpaper and evaluated at 1, 3, and 6 months following treatment for photographs and clinical grading. The side treated with manual dermabrasion showed overall improvement in 80% of cases, with greater improvement specifically in scar color and elevation. Scar width was not significantly affected. The only adverse effect reported was temporary postinflammatory hyperpigmentation.

Kidwell et al. explored the use of sandpaper alternatives for manual dermabrasion.⁶ In their 2008 study, electrocautery scratch pads were compared to different grits of sandpaper using an ex vivo pig foot model. Histologic samples from each abraded area were measured for depth of abrasion. Kidwell found that scratch pads, sanding screens, and 60- to 200-grit sandpaper all reached a similar depth of 0.10 to 0.15mm, equivalent to the level of the papillary dermis. Only 400-grit sandpaper differed, reaching a more superficial depth of 0.07 to 0.12 mm.

Electroabrasion

In a case series of 6 patients, Burns et al. introduced electrosurgical skin resurfacing as a safe and effective alternative to dermabrasion for scar treatment.⁷ Scars were treated with a bipolar electrosurgical device 3 to 8 weeks following Mohs surgery and evaluated with a comparison of photos taken at 1 and 2 weeks' and at 1, 3, and 6 months' post treatment. Patients also completed a questionnaire after 6 months. Burns found that all 6 scars showed improved topography and color match, and all patients thought the

procedure had helped. Burns also performed a histological evaluation to assess depth of tissue penetration and residual thermal injury created by the electrosurgical device. Redundant standing cutaneous cones from Mohs procedures were treated with a different combination of power levels and number of passes and then excised for histopathologic examination. Burns found the mean depth of injury was 114.1 μm (SD = 60.7 μm), with minimal difference between the different power settings and number of passes. The electrosurgical effect did not extend to the level of hair bulbs or deeper eccrine ducts, preserving the population of stem cells needed for skin regeneration.

Electrobrasion Step-by-Step

1. Ensure that all preoperative preparation is complete (e.g., photograph, consent).
2. Administer preoperative anxiolytics as needed. For limited treatment sites in areas typically unaffected by herpetic or impetigo outbreaks, prophylaxis is generally not necessary.
3. Clean the treatment area with an antiseptic of choice (e.g., chlorhexidine or betadine). Alcohol should be avoided due to fire hazard.
4. Provide necessary anesthesia with local anesthetic.
5. Abrade the skin with the needle tip of an electrosurgical device (e.g., Hyfrecator 2000, ConMed Co., Centennial, CA) on low power with a setting of 10. A sweeping motion is used to paint the treatment area to the level of the papillary or reticular dermal junction, depending on scar characteristics.
6. After the treatment area is fully ablated, feather the periphery to create a more natural appearing transition zone.
7. Apply Vaseline ointment and hydrogel semioclusive dressing to abraded sites to prevent crust formation until the epidermis is fully reepithelialized. This dressing should be changed every 3 to 5 days.

8. The patient should be instructed to take acetaminophen and ibuprofen as needed for pain.
9. Reepithelialization should take 7 to 10 days, after which make-up can be applied. Patients should be instructed on strict sun avoidance and can be started on retinoic acid and hydroquinone 3 weeks following the procedure.

Campbell and Eisen used electroabrasion with a monopolar device and reported efficacy in the treatment of contour irregularities resulting from a paramedian forehead flap and full-thickness skin graft repair following Mohs surgery.⁸ No histological evaluation was made in this study. They noted several advantages of electroabrasion with a monopolar device, reporting decreased cost, ease of use, and absence of blood splatter.

Comparative Trials

Recently, randomized controlled studies have been conducted to compare the efficacy of dermabrasion versus other approaches to scar treatment, such as manual dermabrasion, electroabrasion, chemical peels, and laser. Some have also advocated a combination approach to the treatment of facial scarring.

Dermabrasion versus manual dermabrasion

Using a split scar study, Gillard et al. randomly assigned 21 patients to receive traditional dermabrasion with diamond fraise to one-half of the scar and manual dermabrasion with drywall sanding screen to the other half.²⁵ All scars were on the face and a majority (18/21) were on the nose. Repairs included scars healing via secondary intention, complex linear closures, full-thickness skin grafts, and flap closures. Patients were evaluated at 1, 2, 3, and 4 weeks, and 3 and 6 months to assess for percentage of skin reepithelialization, skin erythema, presence of milia, scar-line visibility, contour, presence of infection, pain score, and presence of hypertrophic scar. No differences were found between the two treatment modalities overall or at any of the time points.

Electroabrasion versus manual dermabrasion

Kleinerman et al. evaluated electroabrasion using a monopolar electrosurgical device versus manual dermabrasion using medium grit drywall cement paper in a split scar study enrolling 33 patients.²⁶ Scars were assessed at 3 months following treatment using the Manchester Scar Scale, a validated scar assessment instrument.²⁷ Significant improvement in scar outcome from baseline was reported for both techniques, with no significant difference seen between electroabrasion and manual dermabrasion.

Chemical peel versus dermabrasion

Several groups have studied the histologic and immunohistochemical changes between the use of chemical peels and dermabrasion. El-domyati et al. treated the faces of four patients with trichloroacetic acid peel (TCA 10%, 20%, and 30%) and five patients with dermabrasion.²⁸ Biopsies were taken at 3 months post procedure for examination under electron microscopy, H&E staining, and immunohistochemical staining. They found that while both techniques produced increased collagen deposition and normalization of elastic tissues, changes were more prominent in patients treated with dermabrasion.

Giese et al. used a porcine model to examine differences between dermabrasion and TCA 25%, TCA 50%, and Phenol peels.²⁹ At 6 months, no significant difference in elastic tissue volume was found in the dermabrasion and TCA groups. However, the phenol peel group demonstrated a decrease in elastic tissue volume, which the authors concluded was an unintended but potential risk of deeper peels.

Laser versus dermabrasion

In 1998, Nehal et al. compared the efficacy of unfractionated CO₂ laser to dermabrasion in resurfacing facial scars in a split scar study of four patients.³⁰ At 8 weeks following treatment, there was no significant difference between the treatment sides. Nehal reported that the side treated with CO₂ laser had the advantage of being bloodless and resulted in less crusting postoperatively, although both sides had the same outcome.

Christophel et al. also utilized a split scar study to compare fractionated CO₂ laser to dermabrasion in 6 patients with 12 scars.³¹ There were no long-term differences at 3 months, although the CO₂ laser group demonstrated less

erythema, bleeding, and edema in the period immediately following treatment.

PATIENT EVALUATION AND PREPARATION

Indications

Dermabrasion has been indicated for the treatment of multiple conditions (Table 56-1). For scars, the ideal treatment period is 6 to 8 weeks following injury, though some surgeons prefer dermabrasion significantly later. For deeper scars and professional tattoos, dermabrasion can be used as an adjunct to laser treatment, though scarring is more likely when it is used in this manner.

Table 56-1. Indications for Dermabrasion

Scars—postacne, traumatic, surgical
Tattoos—professional, amateur, traumatic
Telangiectasias
Melasma
Epidermal nevi
Adenoma sebaceum
Actinic keratoses
Syringomas
Rhytides
Cysts and milia
Trichoepitheliomas
Rhinophyma
Recalcitrant acne
Seborrheic keratoses

Data from Mandy S, Gross KK, Yarborough JM. Guidelines of care for dermabrasion. *J Am Acad Dermatol*. 1994;31(4):654–657.

History and physical examination

A complete history and physical examination should be conducted (Tables 56-2 and 56-3). Patients with a history of mild bleeding diatheses may benefit from electroabrasion or laser treatment, as these procedures generally produce a less bloody field. In general, none of these procedures should be performed in those with serious bleeding disorders. In addition, a history of blood borne illnesses such as HIV or Hepatitis B or C should be sought out, as the operator may be exposed to significant blood splatter during the dermabrasion procedure. Dermabrasion should be conducted with caution in immunosuppressed individuals, given the risk for infection and delayed wound healing. Prophylaxis with antibiotics (cephalexin 1–2 g daily for 10–14 days) should be considered in patients with a history of impetigo or staphylococcal infections. Similarly, patients with a prior history of herpes simplex virus may be given acyclovir or valacyclovir prophylactically. Though the evidence for abnormal scarring in those who take isotretinoin is largely anecdotal, many would consider delaying any ablative procedure such as dermabrasion or electroabrasion in those who have taken isotretinoin within the last 6 to 12 months.²³ In a patient who has a history of keloid formation, or a koebnerizing condition such as psoriasis, lichen planus, or vitiligo, a test spot should be considered prior to full treatment.

Table 56-2. Important History Elements for the Dermabrasion Patient

Clotting disorders or bleeding
Herpes simplex or other infections
Hypertrophic or keloidal scarring
Adverse reaction to medications
Cold intolerance
Lupus erythematosus
Immunosuppression
Koebnerizing conditions
Recent history of taking isotretinoin (Accutane)
Use of any systemic medications that interfere with clotting, and/or drugs that may potentiate or interfere with analgesics and/or anesthetics
Use of topical medications

Data from Mandy S, Gross KK, Yarborough JM. Guidelines of care for dermabrasion. *J Am Acad Dermatol*. 1994;31(4):654–657.

Table 56-3. Important Physical Examination Elements for the Dermabrasion Patient

The skin should be examined for the following:
Tone
Elasticity
Symmetry
Signs of previous normal or abnormal healing
Specific pathology in the area to be treated, such as
— Scarring
— Pigmentary alterations
— Telangiectases
— Bacterial or viral infections (e.g., verrucae, molluscum, herpes simplex)
Pigmentation

Data from Mandy S, Gross KK, Yarborough JM. Guidelines of care for dermabrasion. *J Am Acad Dermatol*. 1994;31(4):654–657.

Physical examination should be directed at examining the area to be treated for tone and elasticity. If the skin is easily distensible, the patient may be better served with a tightening procedure (e.g., fractionated CO₂ laser). However, if the skin is rigid and the contour irregularities remain fixed (e.g., deeply pitted acne scarring or pincushioning on the nose), dermabrasion is a reasonable choice. Photographs before treatment are recommended to document the degree of pre-existing scarring or pigmentary alterations in the area to be treated. Although dermabrasion is not limited by skin pigmentation, patients with darker skin may be at increased risk of postinflammatory pigment alteration.

Preoperative preparation and postoperative care

Attention to adequate preoperative preparation and postoperative care is essential to provide the best outcomes for patients (Tables 56-4 and 56-5). All patients should receive appropriate education, and informed consent should be obtained. Preoperative and postoperative photographs in a standardized format (see Chapter 8) are recommended. Patients with a

history of anxiety may benefit from preoperative anxiolytic such as lorazepam 0.5 to 1mg. However, it is important to obtain consent prior to the patient taking any anxiolytic. Local anesthesia with lidocaine with epinephrine 1:100,000 is generally sufficient for the treatment of a targeted area, though full face dermabrasion may benefit from the use of tumescent anesthesia and local nerve blocks.

Table 56-4. Preoperative Preparation

Anesthesia
– Local and/or topical
– Local with sedation (oral, intramuscular, or intravenous)
– Cryoanesthesia
– Regional nerve blocks
Medications
– Acyclovir/valacyclovir prophylaxis
– Antibiotic prophylaxis as needed
– Consider delaying procedure if isotretinoin used in last 6–12 months

Table 56-5. Postoperative Care

Hemostasis
Biosynthetic dressings
Anti-inflammatory medications
Analgesics
Postoperative activity restriction
Sun protection
Antibiotics

Postoperatively, patients should be meticulous with skin care to promote wound healing and to detect early signs of impending complications. Mild postprocedural bleeding can be managed with lidocaine with epinephrine-soaked gauze which can also provide an element of analgesia. Systemic corticosteroids may be used to reduce facial swelling and patient discomfort in larger cases, though evidence is lacking to the safety and efficacy of this

approach. Pain is generally limited to the immediate postoperative period, and responds well to over-the-counter medications such as ibuprofen or acetaminophen, though narcotics may be prescribed as needed. Increased pain or significant erythema after 2 to 3 days is unusual, and may indicate an incipient herpetic or bacterial infection. A biosynthetic dressing maybe placed to decrease healing time and degree of pain.³² Dressings may be changed in the office, or the patient can be instructed on how to perform dressing changes at home with the use of dilute vinegar soaks in between changes to remove any crusting.³³ Patients must practice strict sun protection during the healing period to help decrease the risk of dyspigmentation.^{1,34} If indicated by patient history or physical examination, antibiotic and antiviral prophylaxis can be prescribed. Patient should be instructed to refrain from using makeup until reepithelialization is complete.

TECHNIQUE

Dermabrasion

Choice of an abrading end piece depends on the treatment area being resurfaced (Fig. 56-1). Cone-shaped fraises may be used in smaller areas that require increased precision such as around the eyes and mouth. In contrast, broader wheel-shaped diamond fraises or a wire brush may be used on larger areas such as the cheeks and forehead. The wire brush is generally the most abrasive end piece (Fig. 56-2). A splash guard can be added to protect from blood splatter (Fig. 56-3).



Figure 56-1. From left to right: Splash guard attachment, diamond fraises $\times 2$, pear-shaped or cone fraise. (Used with permission from David Zloty, MD).

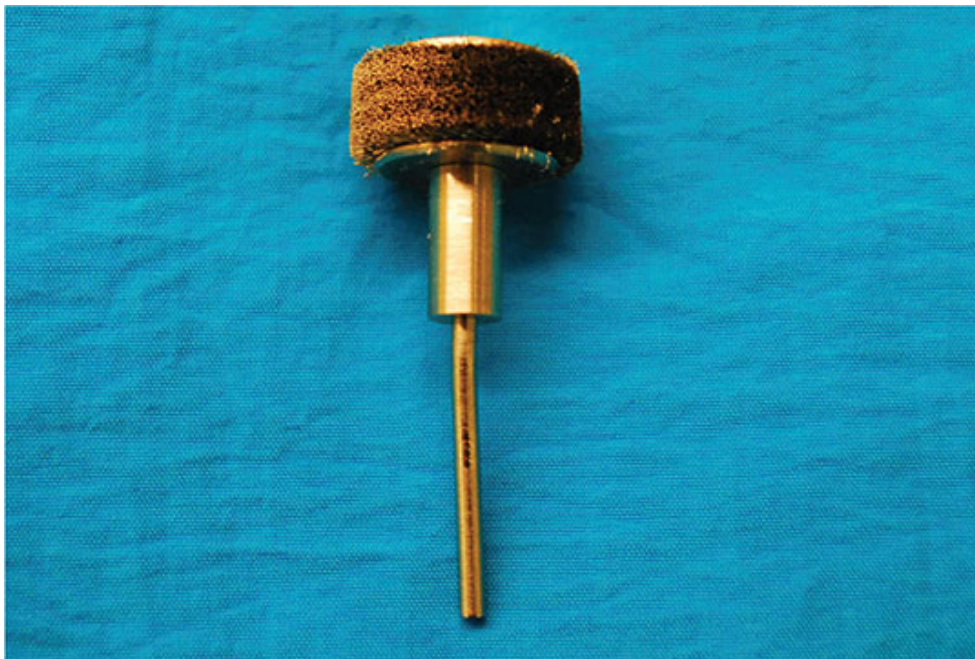


Figure 56-2. Wire brush head.



Figure 56-3. Hand engine hand piece with diamond fraise tip and splash guard in place.

Hand engines are manufactured by multiple makers (Bell, Ellis, Osada, Schumann). These devices are capable of 18,000 to 35,000 rpm. The hand piece is attached to the hand engine via a wired connection for electrical units (Fig. 56-4). Some units are battery powered, which allows for greater mobility, often at the expense of lesser rpm (Fig. 56-5).



Figure 56-4. Bell hand engine unit with hand piece in holster.

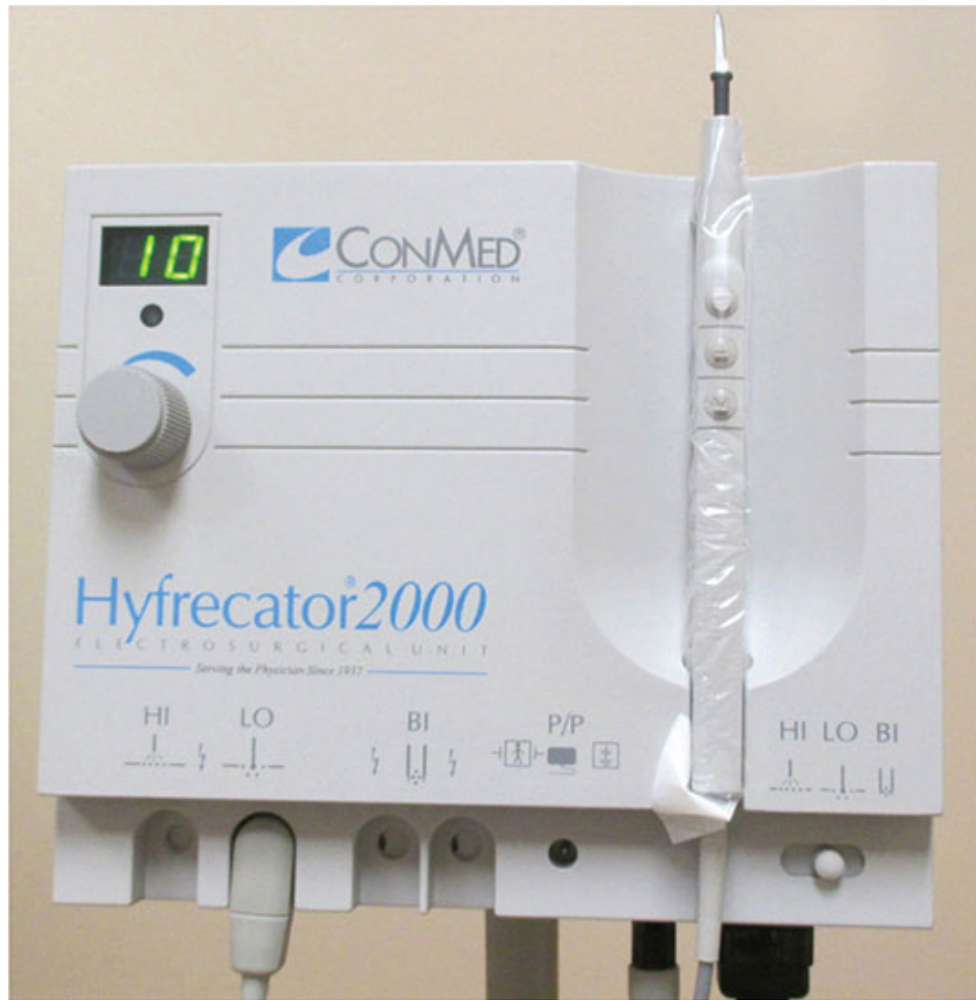


Figure 56-5. Electrosurgical skin resurfacing device (Hyfrecator 2000, ConMed Corp, Utica, NY). Low output terminal and power setting of 10 is used.

The body of the engine hand piece should be grasped with the forefingers while the thumb stabilizes its neck (Fig. 56-6). The hand piece should be pulled perpendicular to the direction of the end piece rotation in arciform strokes. The direction of rotation is important when using the wire brush; when the brush bristles rotate clockwise, the end piece will cut deeper. This requires the surface to be rigid and pretreated with refrigerant and adequate anesthesia. When using a wire brush in a counterclockwise direction, the strokes are easier to control, and the depth of abrasion is more superficial. When using a pear- or cone-shaped fraise, the hand piece should be held as if holding a pencil (Fig. 56-7).

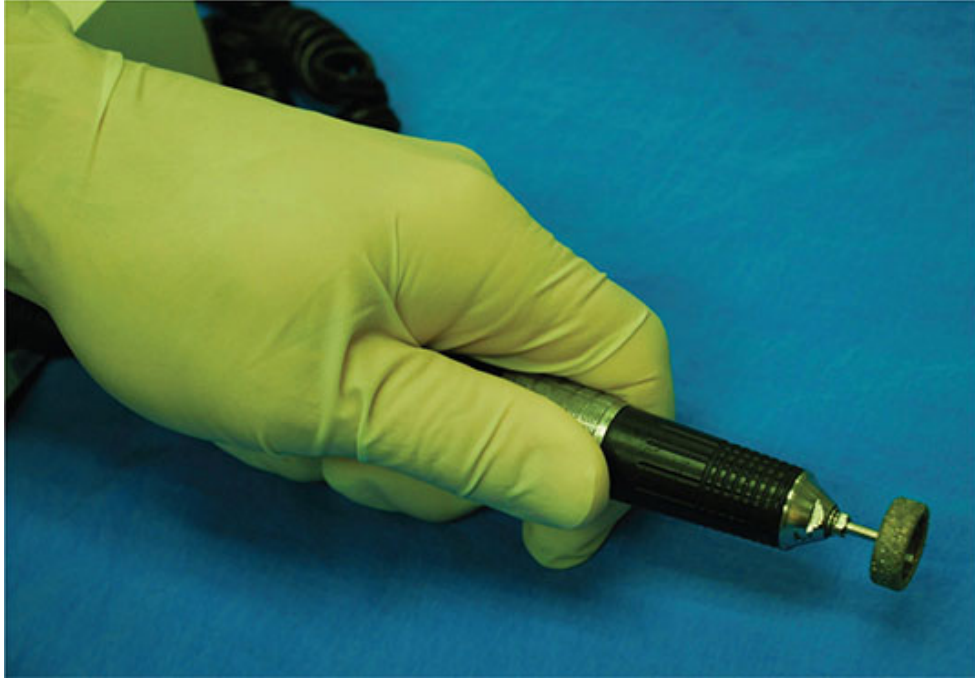


Figure 56-6. Technique for holding hand engine with diamond fraise tip. The body of the hand engine is grasped by the thumb and index finger while the rest of the fingers provide support. Strokes are made perpendicular to the rotation of the fraise tip.

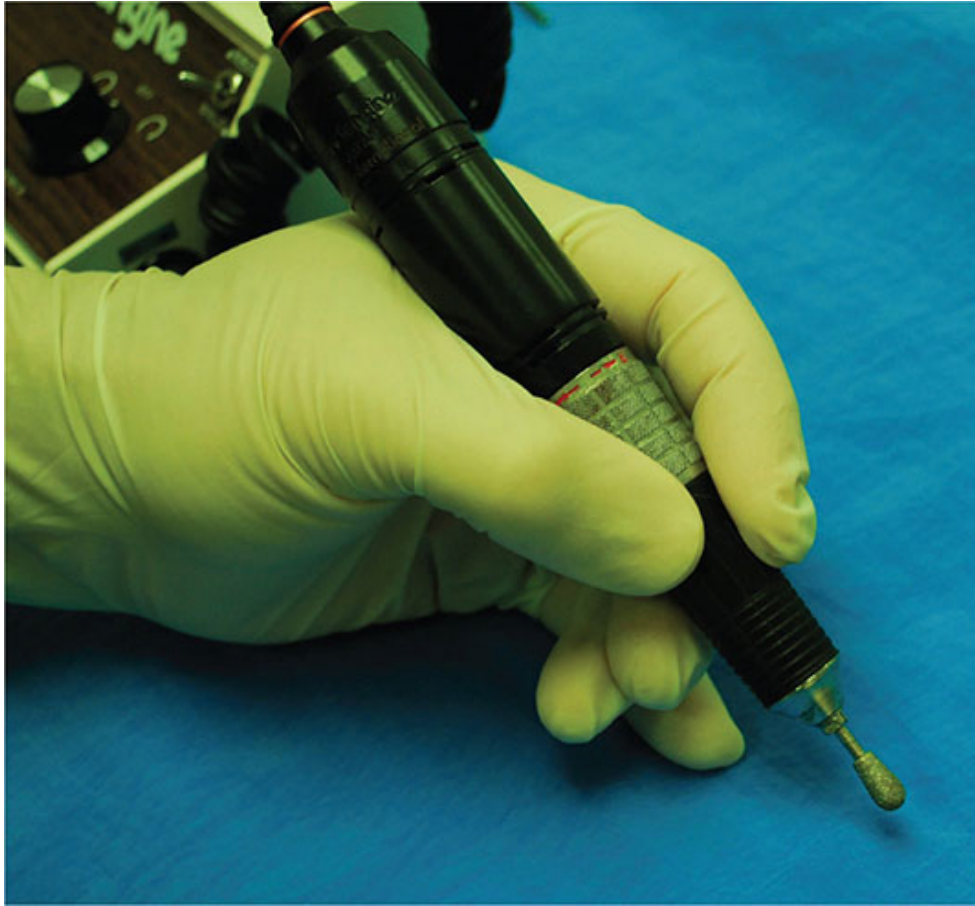


Figure 56-7. Technique for holding hand engine with cone fraise tip. The body of the hand engine is held similar to a pencil. Strokes can be made in any direction.

Prior to dermabrasion, some advocate painting the surface of the skin with gentian violet. In addition to its role as an antiseptic, the removal of gentian violet can be an effective aid to assessing depth of abrasion.³³

An assistant should be available to assist with spraying cryogenic spray to provide a firm surface for dermabrasion. No more than 10 to 15 seconds of freezing time is recommended. This should be done only to areas immediately before abrasion; refreezing and reabrading an area should be avoided.³⁴ In addition, an assistant should help keep the skin taut and blot as needed with cotton towels. Gauze should be avoided as it can be entangled in the dermabrasion end piece.

Dermabrasion should be carried on until punctate bleeding is visualized, representing the level of the papillary–reticular dermal junction (Fig. 56-8). A fine, shredded appearance in the texture of the wound indicates the

superficial portion of the reticular dermis.³³ More superficial resurfacing results in a more limited degree of improvement, while deeper dermabrasion risks increased scarring due to adnexal structures being removed.

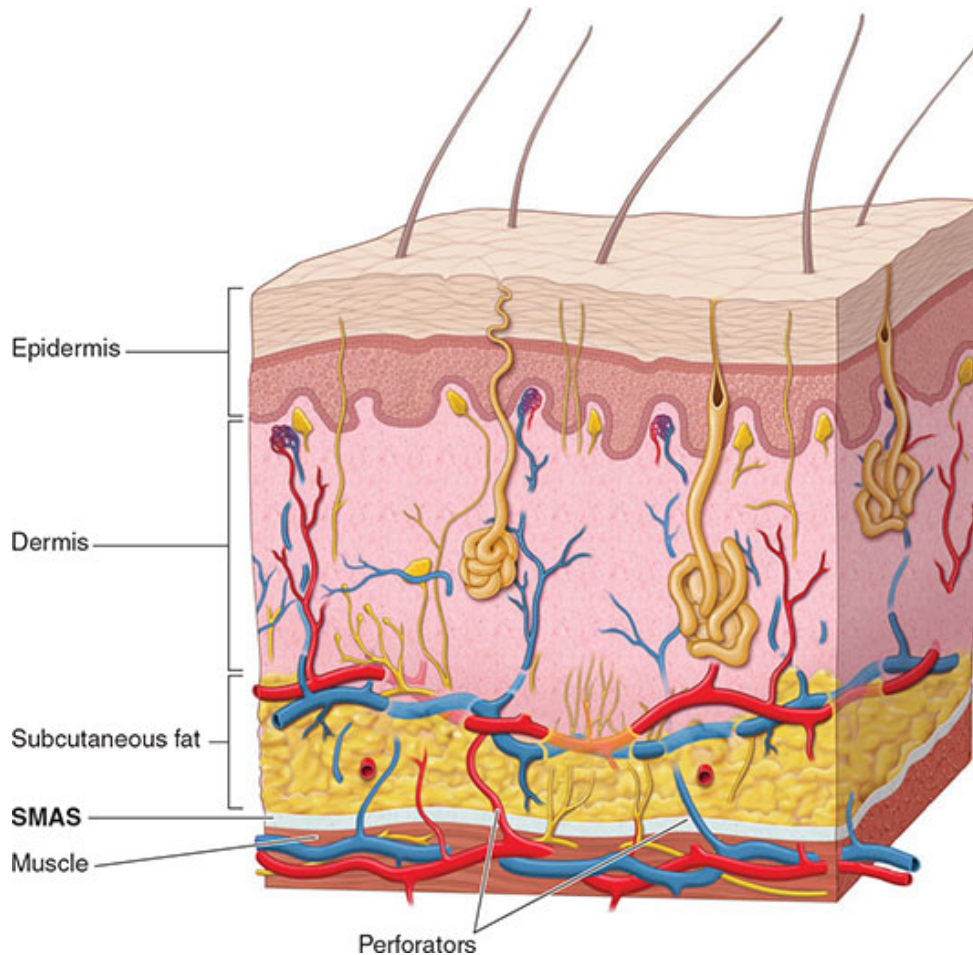


Figure 56-8. Recommended depth of dermabrasion is to the junction of the papillary and reticular dermis.

One should proceed from inferior to superior, as blood from a previously abraded area will flow in a gravitational direction away from the next area to be abraded.¹ It can also be helpful to follow cosmetic subunits. After the treatment area is fully abraded, the periphery should be feathered to create a more natural appearing transition zone.

After dermabrasion is complete, compression with lidocaine and epinephrine-soaked gauze for 5 to 10 minutes can help obtain hemostasis and reduce stinging from the procedure. Appropriate postoperative wound care, including petrolatum ointment and a hydrogel semiocclusive dressing should

be used to prevent crust formation until the epidermis is fully reepithelialized.³⁵ Dilute vinegar soaks and gentle debridement of crust can be performed in between dressing changes.

Manual Dermabrasion

Manual dermabrasion employs the same principles of traditional dermabrasion without the need for a hand engine or skin refrigerants. Several options are available and acceptable as abrasive surfaces. Different grits of sandpaper may be used to achieve slight variations in depth. Drywall/plaster sanding screening⁵ and electrocautery scratch pads⁶ may also be used (Fig. 56-9). The abrasive material should be packaged as sterile or autoclaved prior to use.



Figure 56-9. From left to right: Sandpaper in order of increasing coarseness: 400, 320, 240, 180, 150, and 120 grit. Drywall sanding screen is pictured on the right.

The sandpaper is wrapped around the barrel of a syringe, around a sterile marking pen, or folded in three around the surgeon's index finger (Fig. 56-10).³⁶ A gentle back-and-forth or circular motion should be used to dermabrade the skin.⁵ Continue until punctate bleeding is visualized, as with

traditional dermabrasion. Feathering is performed at the periphery to create a blend with surrounding skin.

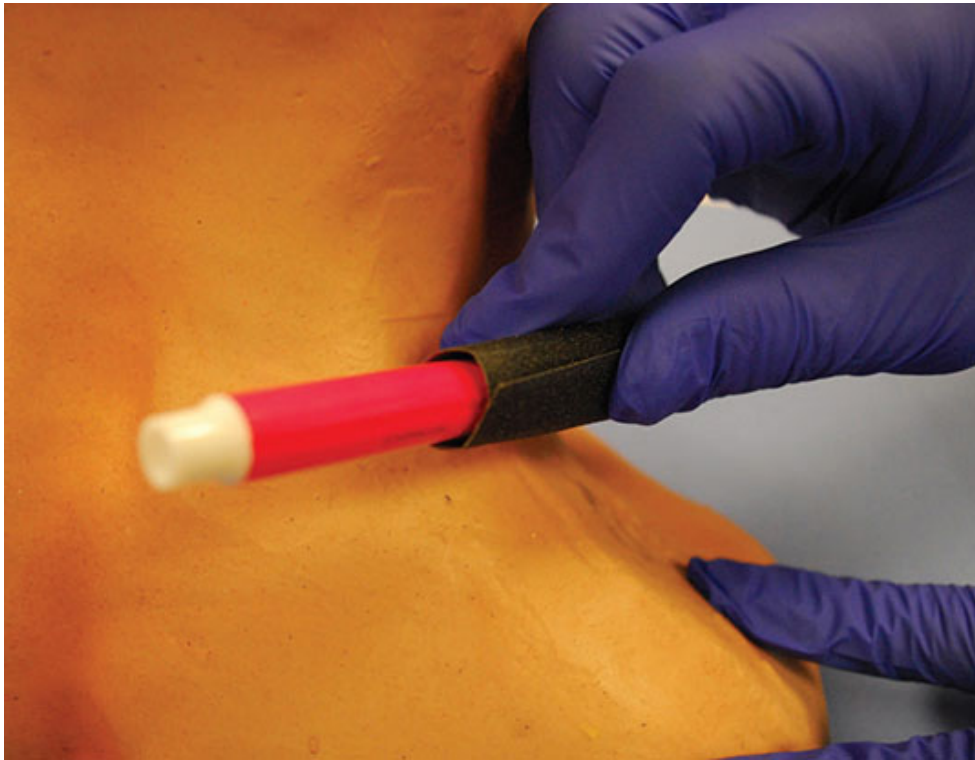


Figure 56-10. Technique for holding sandpaper for manual dermabrasion. The sandpaper is wrapped around a sterile marking pen.

As with mechanical dermabrasion, moving from inferior to superior will keep the untreated site free of blood and make the procedure easier to complete. Lidocaine with epinephrine-soaked gauze should be employed for hemostasis, and dressings should be applied as with traditional dermabrasion. Representative cases are shown in [Figures 56-11 to 56-15](#).

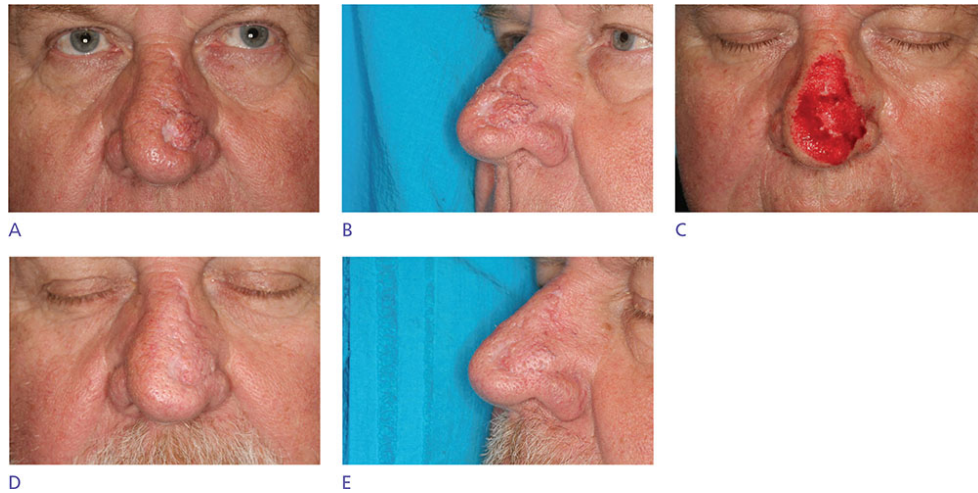


Figure 56-11. (A, B) Pretreatment scar resulting from bilobed flap following Mohs surgery. (C) Immediate posttreatment photo following dermabrasion. (D, E) Follow-up at 8.5 months following dermabrasion. (Used with permission from David Zloty, MD).



Figure 56-12. (A) Pretreatment scar resulting from full-thickness skin graft following Mohs surgery. (B) Immediate posttreatment photo following dermabrasion. (C) Follow-up at 3 months following dermabrasion. (Used with permission from David Zloty, MD).



Figure 56-13. (A, B) Pretreatment scar resulting from full-thickness skin graft following Mohs surgery. (C, D) Immediate posttreatment photo following dermabrasion. (E, F) Follow-up at 5 months following dermabrasion. (Used with permission from David Zloty, MD).



Figure 56-14. (A) Pretreatment scar resulting from full-thickness skin graft following Mohs surgery. (B) Immediate posttreatment photo following dermabrasion. (C) Follow-up at 3 months following dermabrasion. (Used with permission from David Zloty, MD).

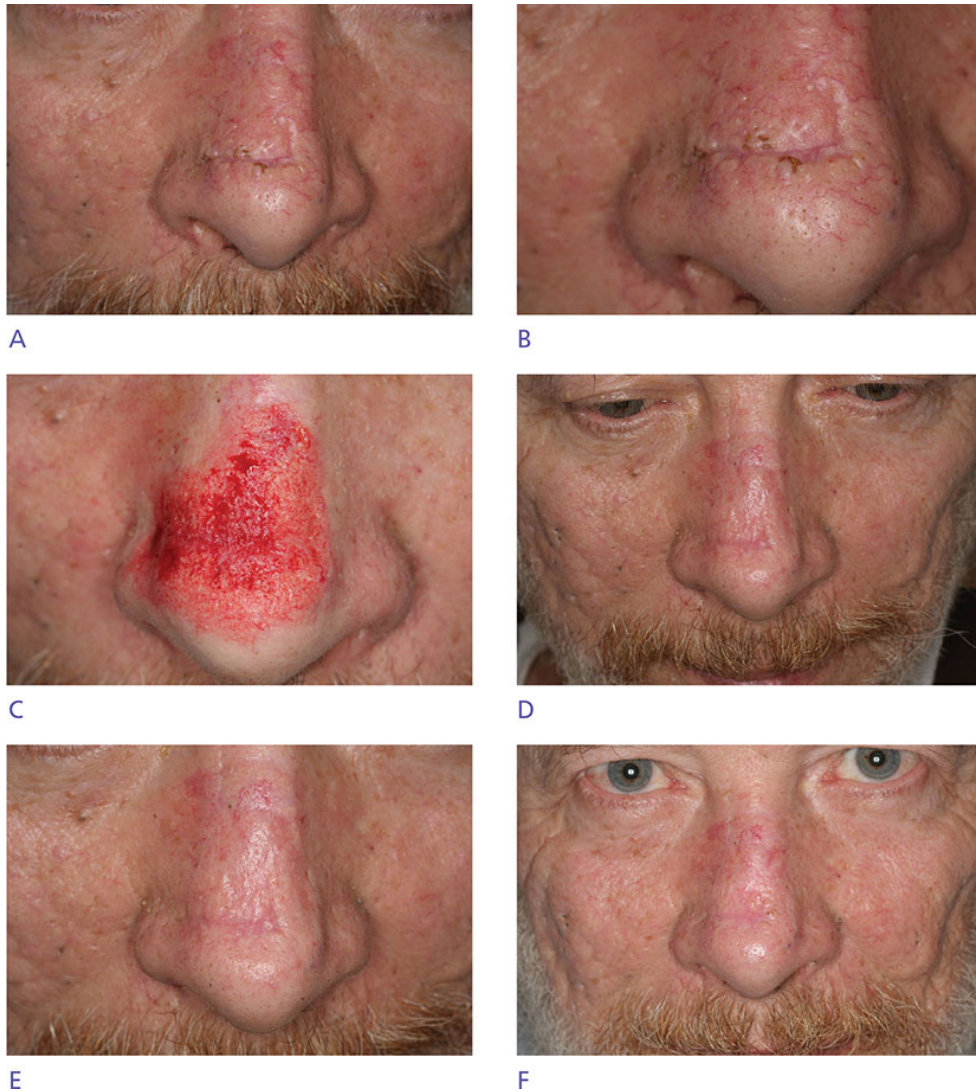


Figure 56-15. (A, B) Pretreatment scar resulting from advancement flap following Mohs surgery. Note multiple open comedones. (C) Immediate posttreatment photo following dermabrasion. (D, E) Follow-up at 3 months following dermabrasion. Note significant improvement of comedones following treatment. (F) Follow-up at 8 months following dermabrasion. Note interval milia formation over dermabraded area. (Used with permission from David Zloty, MD).

Electrobrasion

In electrobrasion, an electrosurgical device is used to ablate the skin. The body of the hand piece is held with the thumb and middle finger, while the index finger is used to trigger the electric current. The grip is similar to holding a pen. The device should be set at low to mid power. Higher settings with multiple passes may result in deeper dermal damage than intended.⁷

Several tips may be used. A smaller, needle point tip is useful for treating fine, small areas. A larger flatter tip can be used to plane down larger areas of tissue, such as in rhinophyma. In electroabrasion of scars, the flat portion of the tip is moved gently across the surface of the skin.⁸ A sweeping motion is used to paint the treatment area to the level of the papillary or reticular dermis depending on the nature of the scar or tissue irregularities to be treated. Unlike dermabrasion, there is minimal bleeding with electroabrasion, and this cannot be used as a landmark for reaching the papillary dermis.

After the treatment area is completely ablated, one should feather the periphery at lower settings to blend in the surrounding skin for a natural appearance. Postoperative care is similar to dermabrasion.

COMPLICATIONS

To optimize outcomes for patients, an understanding of the potential complications that may result from dermabrasion, and the solutions that can be utilized to prevent or fix these problems, is very helpful ([Table 56-6](#)).

Table 56-6. Challenges and Solutions

Pitfalls	Pearls
Infection (viral, bacterial)	– Antibiotic prophylaxis for patients with a history of impetigo. Antiviral prophylaxis for patients with a history of herpes simplex infection – Meticulous wound care regimen, including regular dressing changes, vinegar soaks
Dyspigmentation	– Diligent sun protection following treatment – Hydroquinone treatment – Tretinoin treatment – If treating patients with a darker complexion, ensure that they understand the risk for post inflammatory pigment alteration is greater
Scarring	– Do not dermabrade below the level of the papillary dermis – Dermabrade 6–8 weeks after injury; there is less likelihood of complete scar resolution the further out from injury – Consider delaying treatment in those who have taken isotretinoin in the last 6–12 months prior to dermabrasion – Treat bright red erythema after the first 2–3 weeks following dermabrasion with intralesional steroids or pulsed-dye laser

One of the most common issues following dermabrasion is the development of a bacterial or viral infection. History of impetigo or herpes simplex infection should be elicited during preoperative evaluation to assess the need for prophylactic treatment. If necessary, cephalexin 1 g daily for 10 to 14 days or valacyclovir 1 g daily for 7 to 14 days can be used for this purpose. Infections of any type can extend the depth of injury and lead to

hypertrophic scarring. Patients should be instructed on performing appropriate dressing changes and educated on how to use dilute vinegar soaks to help prevent infection. If a patient is not able to perform this at home, they should follow up daily in clinic for dressing changes and gentle debridement. Infection will usually manifest as significant pain several days after dermabrasion.

Another common problem following dermabrasion is postinflammatory pigment alteration. Along with wound care, diligent sun protection must be emphasized. The use of tretinoin cream 2 weeks preoperatively has been shown to significantly reduce the incidence of milia and postinflammatory hyperpigmentation.³⁷ Hydroquinone can be used to lighten the skin. It is also essential to have a frank discussion regarding the risks of significant dyspigmentation in patients with darker complexions who are interested in proceeding with dermabrasion.

Scarring following dermabrasion can result from both inadequate treatment of preexisting scar or formation of new scarring. The former problem can be optimized by treating the skin 6 to 8 weeks following injury, as this has been shown to be the optimal time for treatment.²² The risk of scarring increases when dermabrasion is performed deep to the level of the papillary dermis, as this will disrupt the population of stem cells residing around adnexal structures that are necessary for reepithelialization. Bright red erythema 2 to 3 weeks following dermabrasion can be a sign of early scar formation. Intralesional steroid injection and pulsed-dye laser may be used to improve scar outcome (Figs. 56-16 to 56-20).³⁸



Figure 56-16. (A) Pretreatment scar resulting from full-thickness skin graft following Mohs surgery. (B) Side A randomized to manual dermabrasion and side B randomized to electroabrasion. (C) Follow-up at 3 months following treatment showing improvement in scar with both treatment modalities.

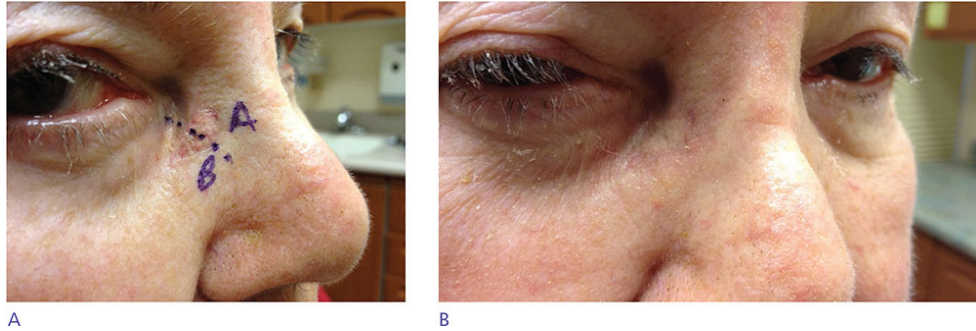


Figure 56-17. (A) Pretreatment scar resulting from full-thickness skin graft following Mohs surgery. Side A randomized to manual dermabrasion and side B randomized to electroabrasion. (B) Follow-up at 3 months following treatment showing limited improvement in scar with both treatment modalities.

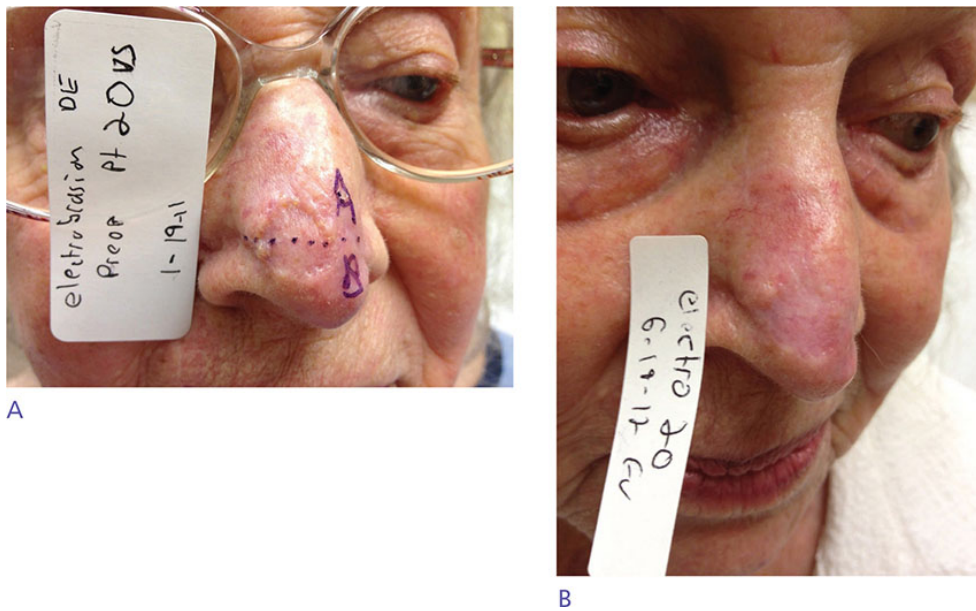


Figure 56-18. (A) Pretreatment scar resulting from full-thickness skin graft following Mohs surgery. Side A randomized to manual dermabrasion and side B randomized to electroabrasion. (B) Follow-up at 3 months following treatment showing limited improvement in scar with both treatment modalities.

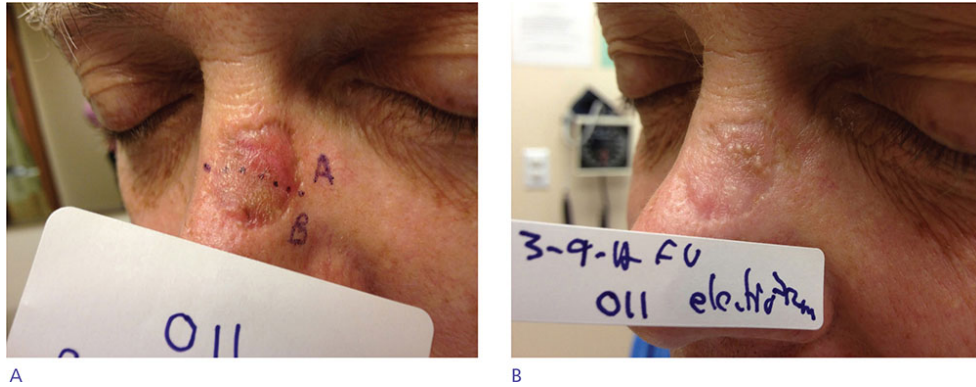


Figure 56-19. (A) Pretreatment scar resulting from full-thickness skin graft following Mohs surgery. Side A randomized to manual dermabrasion and side B randomized to electroabrasion. (B) Follow-up at 3 months following treatment. Note development of milia in side treated with dermabrasion.

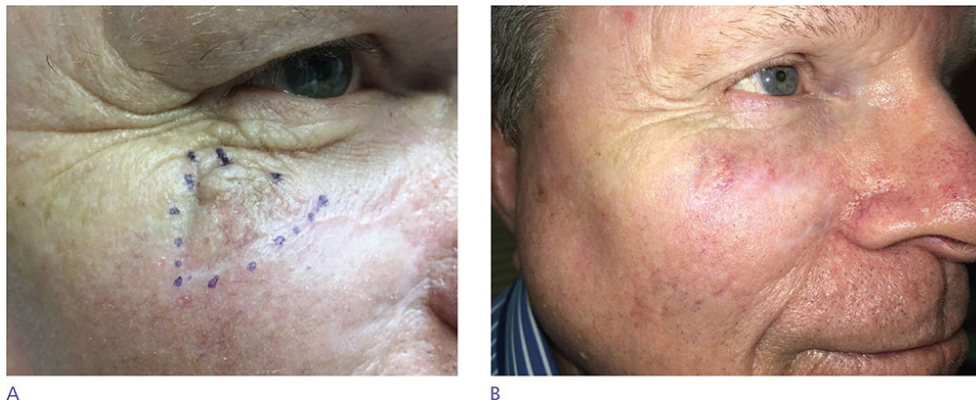


Figure 56-20. (A) Pretreatment scar resulting from advancement flap following Mohs surgery. (B) Follow-up at 3 months following treatment with electroabrasion.

CONCLUSIONS

Dermabrasion is an important technique that is used widely in dermatologic surgery. Manual dermabrasion is generally performed in the postoperative period to improve scar appearance, and is particularly well suited to the treatment of flap and graft sites when pincushioning or textural or color mismatch is pronounced. Traditional dermabrasion may be utilized as a full-face approach, though it should always be weighed against the potential role for laser resurfacing or medium depth chemical peels. Electroabrasion is another option that is easy to perform in an office setting and does not require additional instruments; regardless of approach, patients should be warned

regarding the potential risk for serious complications in the posttreatment period, and should be highly motivated and educated prior to proceeding with the procedure.

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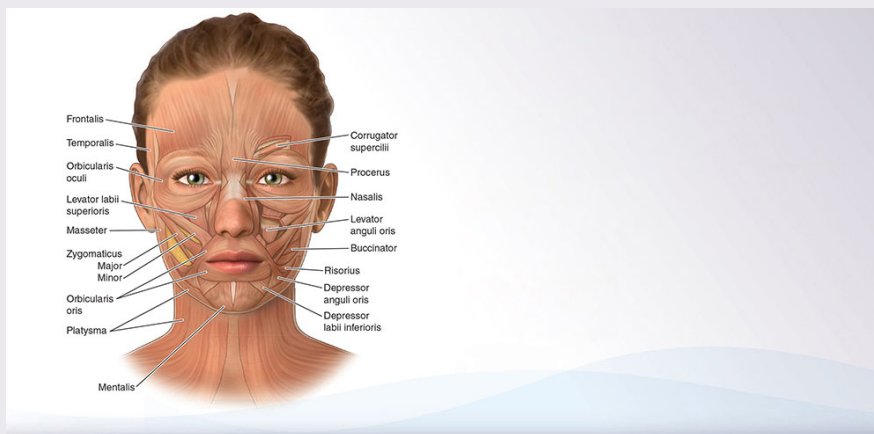
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CHAPTER 57 Neuromodulators

Douglas C. Wu



SUMMARY

- The most popular dermatologic uses of BTX include the reduction of facial rhytides, facial contouring, and treatment of focal hyperhidrosis. It is commonly used for the following areas of the face:
 - Upper face
 - Glabellar lines
 - Lateral canthal lines
 - Horizontal forehead lines
 - Bunny lines
 - Infraorbital region
 - Lower face
 - Nasal tip droop

- Nasal flare
- Perioral rhytides
- Depressor anguli oris
- Hypertrophic masseters
- Excessive gum show
- Wrinkled chin

Beginner Tips



- Expert consensus guidelines recommend that a vial of BTX can be refrigerated or refrozen for at least 4 weeks before injection without significant risk for contamination or decreased effectiveness, and that a single vial can be used to treat multiple patients, assuming appropriate handling.
- Using preservative-containing sterile normal saline for reconstitution significantly reduces subsequent injection pain and is therefore recommended.

Expert Tips



- Variations in muscular patterns in the upper face are well established, and studies have demonstrated that targeted individualized treatment delivers superior outcomes.
- Due to the interrelationship between the facial musculature, it is useful to conceptualize the upper and lower face as global treatment regions rather than focus on a specific area such as the glabella or lateral canthus. This mindset promotes the goal of achieving a harmonious, balanced, natural, and aesthetically pleasing outcome.

Don't Forget!



- Simple mechanical distraction administered by an assistant tapping on the patient's shoulder or forehead during injections is a highly effective and efficient way to decrease injection pain.
- Brow ptosis is especially common in those with smaller foreheads, naturally low brows, minimal frontalis bulk, or with a tendency to overutilize the frontalis muscle for brow elevation during facial expressions.

Pitfalls and Cautions



- Cultural and ethnic norms should also be taken into account when tailoring individual treatments, as desires and expectations can vary significantly between these diverse populations.
- Inferolateral extension of lateral canthal lines down toward and across the zygoma should not be “chased” with BTX due to the risk of facial asymmetry.

Patient Education Points



- Important areas to consider include: establishment of realistic goals, assessment of desired treatment area, understanding of expectations and potential side effects, written informed consent, and photographic documentation.
- Photographic documentation is highly recommended for both pre- and posttreatment status.

CHAPTER 57 Neuromodulators

INTRODUCTION

Botulinum toxin (BTX) is one of the most widely used aesthetic treatments available to dermatologists and dermatologic surgeons. When appropriately applied, its safety, efficacy, reproducibility, and overall satisfaction are exceptional.

Although the toxin itself was isolated in the 1940s, early work with BTX for medical purposes began in the 1970s and 1980s with the pioneering research of Dr. Alan Scott on strabismus and blepharospasm. Experiments in monkeys¹ laid the groundwork for successful clinical trials in humans.^{2,3} In 1989, BTX received Food and Drug Administration (FDA) approval for blepharospasm and nystagmus.

In parallel with the above efforts, the ophthalmologist–dermatologist, wife–husband team of Jean and Alastair Carruthers made an unexpected discovery: a subject being treated for blepharospasm in a clinical trial reported that BTX therapy also seemed to give her an untroubled, unworried appearance.⁴ Seizing upon this observation, the Carruthers explored the potential of BTX therapy for aesthetic concerns and published their initial work in 1992.⁵ This report spawned the ensuing decades of research and refinement of the dermatologic uses for BTX. In the present day, BTX therapy forms a cornerstone in the dermatologic surgeon’s armamentarium for facial rejuvenation and beyond.

Types of BTX

There are currently three BTX type A preparations that are FDA approved for dermatologic use: onabotulinumtoxin (ONA, Botox Aesthetic, Allergan),

abobotulinumtoxin (ABO, Dysport Aesthetic, Galderma), and incobotulinumtoxin (INCO, Xeomin, Merz), as well as one BTX type B preparation that is FDA approved for cervical dystonia (rimabotulinumtoxin, Myobloc, Elan Corp, Dublin, Ireland). Other BTX preparations are available in different regions of the world. Types of BTX are summarized in [Table 57-1](#).

Table 57-1. FDA-Approved Botulinum Toxins

	Botox	Dysport	Xeomin	Myobloc
Generic name	OnabotulinumtoxinA	AbobotulinumtoxinA	IncobotulinumtoxinA	RimabotulinumtoxinB
Active substance	Botulinums toxin type A	Botulinums toxin type A	Botulinums toxin type A	Botulinums toxin type B
FDA indications	Blepharospasm, cervical dystonia	Cervical dystonia, temporomandibular disorder	Cervical dystonia, temporomandibular disorder	Cervical dystonia

BTX: Structure and function

Seven different serotypes of BTX exist and are labeled A, B, C₁, D, E, F, and G. All serotypes exhibit a similar molecular structure. The toxin is produced as an inactive 150 kiloDalton (kDa) single chain protein that undergoes tissue proteolysis to form a 100-kDa heavy chain and a 50-kDa light chain which serves as a zinc-dependent protease. This di-chain complex is held together by a disulfide bond. The active molecule has a variety of different effects including inhibition of the presynaptic neuromuscular junction, alteration of fibroblast function, and modification of skin mechanical properties.

Neuromodulation

The most well-known function of BTX is its inhibition of acetylcholine (Ach) release at the presynaptic neuromuscular junction. This mechanism of action involves three discrete stages: binding, internalization, and prevention of neurotransmitter release.⁶ Both the 50-kDa and 100-kDa active components have unique roles in these stages. Binding of the presynaptic receptor is triggered by the 100-kDa heavy chain which then induces

Masseteric hypertrophy conveys the impression of heaviness and squaring of the lower face. Genetic predisposition and mastication habits contribute to the development of this feature that is often considered aesthetically displeasing, especially in women as it can masculinize the face. A significant body of evidence supports the use of BTX in the reduction of unwanted masseteric hypertrophy. All commercially available type A botulinum toxins have been utilized successfully for this purpose.^{70,82,83} Anatomic considerations should be taken into account when selecting the appropriate injection points for neuromodulator contouring of the masseters.⁸⁴ Misplaced injections can result in disturbance of the risorius muscle and resultant facial asymmetry. Injection of neuromodulators deep and directly into the belly of the masseter muscle may diminish the risk of unwanted diffusion. The following technique can be used to optimize safety and efficacy of treatment in this area. First, palpate the point of maximal muscle hypertrophy upon clenching along the mandibular border and mark this as the primary injection point. Next, administer two adjunctive injections approximately 1 cm superolateral and 1 cm superomedial, in the shape of an inverted triangle, keeping the superomedial injection point 1 cm posterior to the medial border of the masseter. By remaining inferior and lateral along the muscle, the risk of adversely affecting the zygomaticus major and risorius muscles is decreased. A total of 20 to 30 units of ONA may be injected into each muscle initially, depending on the degree of hypertrophy. Utilization of multiple injection points as opposed to single injection minimizes the risk of imbalanced muscle atrophy (Fig. 57-11). A follow-up visit is scheduled 4 weeks after injection for additional slimming of the muscle if necessary to achieve the desired facial contour (Fig. 57-12).



Figure 57-11. Imbalanced atrophy of the masseter muscle. This patient was treated with a single injection point into the masseter muscle and developed excessive atrophy at that point while simultaneously developing relatively abnormal hyperactivity in untreated areas. Left panel: At rest. Middle panel: Clenching the jaw. Right panel: Clenching the jaw at 45-degree angle photograph.



Figure 57-12. Before and after masseter muscle reduction. Note the slimming of the lower face contour, a subtle but pleasing aesthetic effect.

' RZ QMUHG RUDORP P LWXUHV

The depressor anguli oris (DAO) originates at the outer surface of the mandible posterior to the oblique line and inserts into the modiolus at the angle of the mouth. It is innervated by the mandibular branch of the facial nerve and serves primarily to depress the oral commissure. A hyperactive DAO contributes to the accentuation of the melomental fold (marionette line)

and creates an impression of disapproval and sadness. It can also lend an appearance of an aged lower face. Chemodenervation of the DAO via application of ONA can improve this appearance and create the impression of a more youthful and vibrant outlook. However, placement and dosage of medication must be carefully considered. The modiolus is an insertion point for several key muscles of facial expression, including the zygomaticus major, risorius, levator anguli oris, orbicularis oris, DAO, and depressor labii inferioris (DLI). As such, misplacement of neuromodulator in this area has the potential to negatively alter expressivity, phonation, and facial symmetry. Recent anatomical studies have shed light on the appropriate location for safe injection of neuromodulator targeting the DAO.⁸⁴ Prior to injection, to avoid treatment of the DLI when injecting along its insertion on the mandible, patients are asked to pull down the corners of their mouths to aid in the location of the DAO. Following this landmark identification, 4 units of ONA are injected into the DAO on each side along the mandibular border staying 1 cm lateral to the oral commissure.⁸⁵ In this fashion, the fan-shaped belly of the DAO is most accurately targeted while minimizing the possibility of medication diffusion affecting adjacent musculature.

&KLQZUQNQQJ

The mentalis muscle is the primary evertor of the lower lip and also serves to elevate the skin of the chin. Its fibers intermingle with the orbicularis oris and DLI.⁸⁶ A hyperdynamic mentalis muscle can create unwanted wrinkling and creasing with a peau d'orange appearance. Appreciation of this effect is best noticed when the patient is performing facial expressions. Correction of this phenomenon can be achieved with the injection of either 4 units of ONA directly into the insertion point of both bellies of the mentalis muscle centrally on the mandible or 2 units of ONA into each belly of the muscle, staying close to the midline to avoid spread to the DLI (Fig. 57-8). It is also important to place injections deep to avoid the more superficial DLI.

1 HFN DQGFKHWV

Excessive platysmal banding is an increasingly common problem with aging. The vertical banding is a result of platysmal muscle hypertrophy. Treatment of this area should be performed in a series of injection points delivered superficially. Injections begin at the jawline and proceed inferiorly along the band with approximately 2 cm spacing. Each injection point should deliver 5

to 10 units of ONA and the maximum dose per side should not exceed 50 units (Fig. 57-13).^{78,87}

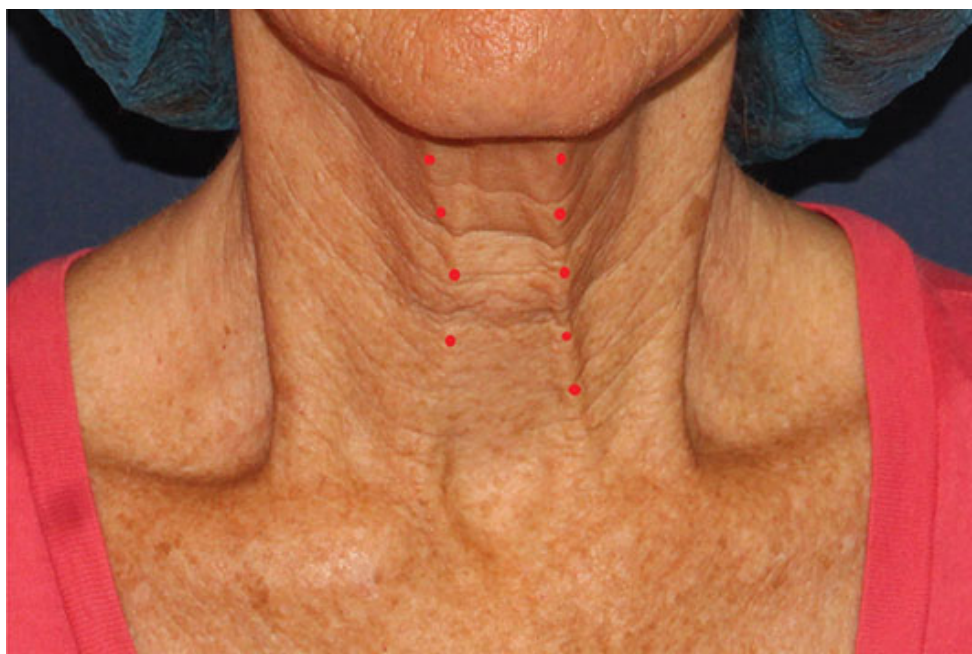


Figure 57-13. Platysmal band injection. Once again, treatment should be tailored to match each individual's unique anatomical variations.

Décolleté wrinkles have also been shown to respond to BTX therapy. In this setting, a V-shaped pattern of injection points following the distribution of “necklace lines” should be utilized. Each injection is delivered at a depth of 4 mm with 5 to 10 units of ONA per injection site. The total dosage typically ranges between 75 and 120 units.^{78,87} Interestingly, flushing of the chest may also respond and improve with this treatment.⁸⁸

OTHER APPLICATIONS

Other uses of BTX therapy that may present to an aesthetic dermatologic clinic include migraine treatment,^{89,90} hyperhidrosis,^{91–93} body contouring,^{94,95} scar revision,⁹⁶ correction of spasmodic facial deformities,⁹⁷ enhancing wound healing,⁹⁸ and mesotherapy.^{88,99}

SPECIAL CONSIDERATIONS

The above recommendations serve as a template for the aesthetic application of BTX therapy. However, the most critical guideline to bear in mind is to always tailor each treatment to the individual anatomical, personal, and cultural preferences of each patient. Appreciation should be given to both gender and ethnic differences. Men tend to have heavier musculature and therefore usually require a higher dosage in order to achieve the same efficacy and longevity. The male aesthetic is also different, especially where it concerns brow shape and jawline. These considerations should be discussed with the patient prior to treatment so that the correct expectations can be set and the necessary adjustments in injection technique can be applied.

Cultural and ethnic norms should also be taken into account when tailoring individual treatments, as desires and expectations can vary significantly between these diverse populations.¹⁰⁰ Asian patients tend to desire a subtler brow arch or no arch at all, and so alterations in glabellar and frontalis injections may be required. Additionally, these patients also place higher importance and benefit more from infraorbit and masseter treatment.^{101,102} Other ethnic preferences that have been studied include Hispanic,¹⁰³ Russian,¹⁰⁴ Indian,¹⁰⁵ African,¹⁰⁶ and Middle Eastern.¹⁰⁷ Once again, the duty of the dermatologic surgeon is to explore these nuances with each patient in order to deliver an optimized treatment regimen.

OUTCOMES AND COMPLICATIONS

In the overwhelming majority of cases, if utilized properly, aesthetic application of BTX is exceedingly safe, effective, and a rewarding experience for both injector and patient. However, as with any cosmetic procedure, appropriate establishment of expectations as well as ability to manage complications are paramount. In order to avoid dissatisfaction, patients need to be counseled on the differences between the immediate short-term benefits of a single treatment and the long-term benefits of continued maintenance therapy. A recent meta-analysis of clinical trials reported that the most common complications of upper face BTX include headache, eyelid ptosis, and heavy eyelids or brow ptosis.¹⁰⁸ Other

complications include “Spock” brow (excessive brow arch), undesired alteration of facial expression, redistribution of muscular bulk in the case of incorrect masseter injection (Figure 57-11), and difficulty with head elevation after overtreatment of platysmal banding. For the most part, these complications can be addressed with judicious balancing treatments with additional neuromodulator. In the case of over-injection, time and supportive measures will reassure the patient that the effect is temporary. Eyelid ptosis can be treated with apraclonidine eyedrops until natural improvement occurs.¹⁰⁹

CONCLUSIONS

BTX remains one of the cornerstones of aesthetic and antiaging medicine. However, current standard of care for advanced practitioners revolves around the combination treatment with neuromodulators, soft-tissue fillers, and energy-based devices.¹¹⁰ In almost every circumstance, the appropriate use of BTX therapy can enhance an aesthetic treatment regimen leading to greater patient benefit and satisfaction.

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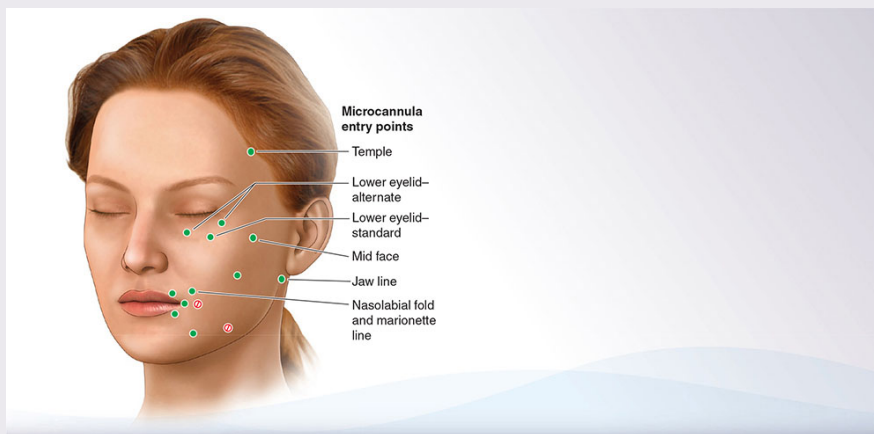
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CHAPTER 58 Fillers and Injectable Implants

Amelia K. Hausauer
Derek H. Jones



SUMMARY

- *Serial puncture technique*: Small aliquots of filler are injected close together so that they integrate continuously along a rhytid or fold. Postinjection massage further facilitates this blending.
- *Linear threading technique*: The full length of the needle is introduced dermally or subcutaneously, and filler is injected linearly

either retrograde (as the needle is withdrawn) or anterograde (as the needle is inserted), which creates a plane of blunt dissection.

- *Cross-hatching or radial injection technique*: Regularly spaced, linear threads created by injecting in more than one direction to form a grid pattern.
- *Fanning technique*: The needle is inserted at a single site then passed multiple times in different directions without fully withdrawing the tip from the skin.
- *Depot injection techniques*: Boluses of filler are injected along the periosteum, usually to correct volume deficiency in the temporal, zygomatic cheek, and chin areas. Postprocedural massage helps prevent nodularity and smooth contour irregularities.

Beginner Tips



- Injection of commercially available hyaluronidase degrades hyaluronic acid filler if it is misplaced (i.e., too superficially), overinjected, or if it produces inflammatory reactions or occludes vasculature.
- Differences in formulation and manufacturing techniques help impart the unique characteristics of each filler.

Expert Tips



- Because of its ability to decrease edema and, consequently, external vessel compression, some recommend hyaluronidase injection irrespective of filler type.
- Sculptra is essentially pulverized polyglactin 910 and can be prepared with as much as 8 to 11 mL of sterile water in >24 hours.
- Calcium hydroxyapatite is radiopaque, though it does not obscure radiographic findings.

Don't Forget!



- Persistent papulonodules are more likely with Sculptra, Bellafill/Artefill, and silicone than other agents.
- Both hypersensitivity and infection with or without biofilm can contribute to the formation of delayed nodules.
- For fat grafts, massage and vigorous dynamic facial movement should be avoided postprocedure.

Pitfalls and Cautions



- Superficial HA can cause a temporary bluish tint due to the Tyndall effect.
- If intralesional hyaluronidase is ineffective or nodules occur in the setting of non-HA augmentation, other reported medical therapies include oral antibiotics (antimicrobial and anti-inflammatory effects); topical, intralesional, or systemic corticosteroids; intralesional 5-fluorouracil; oral immunosuppressants such as cyclosporine; lasers; or combination therapies.

Patient Education Points



- All injectable fillers entail risk; while the risk of serious adverse events is low, it is not inconsequential.
- Patients should have realistic expectations regarding potential outcomes and the need for repeated treatments. Many of the commercially touted before-and-after photos reflect patients treated with large volumes of filler; given the cost, many patients attempt treatment with significantly less volume and should be warned that their results may be less dramatic.
- Though rare, potentially irreversible vascular complications are the most dreaded and serious adverse events following soft tissue augmentation, and patients should understand this possibility and alert the surgeon immediately in the event of any symptoms.

CHAPTER 58 Fillers and Injectable Implants

INTRODUCTION

The use of fillers and injectable implants for facial rejuvenation is one of the most important forms of minimally invasive correction, and represents a key class of interventions for the aging face. These interventions can be largely grouped into the four “R’s”: redrape (surgical procedures that pull, lift, or tighten); resurface (chemical peels, dermabrasion, ablative or nonablative lasers); relax (chemodenervation with neuromodulatory agents); and replace or recontour (injection of filler agents for soft-tissue augmentation). The last has become increasingly popular, as the number of safe, effective dermal filling agents has increased and as the public’s demand for minimally invasive approaches has grown.

Tissue augmentation dates back to the 1890s when Neuber used autologous fat to correct atrophic facial defects.¹ Decades later, Baronders published a review of liquid silicone for permanent-tissue augmentation in 1953, though it was not until 1981 that the US Food and Drug Administration (FDA)-approved bovine collagen as the first implantable/injectable agent for soft-tissue augmentation.² Marketed under the name Zyderm[®] and its successors Zyderm II and Zylplast[®], this xenograft remained the standard of care for more than two decades, but fell out of favor with the introduction of new classes of injectables. Bovine collagen is no longer available in the United States due to high manufacturing costs, limited duration of efficacy (2–4 months)³, and risk of hypersensitivity in approximately 3% of patients.⁴

Bovine collagen products are historically important, nonetheless, since they served as comparators in the pivotal phase 3 clinical trials for most modern-day fillers.

FDA approval of the first hyaluronic acid (HA) filler, Restylane[®], in 2003 marked the beginning of a new period in injectable agents for facial rejuvenation. HA fillers quickly supplanted all other products. Current FDA-approved formulations fall into three families: Restylane/Perlane[®] (now marketed as Restylane Lyft), Juvederm/Juvederm Voluma[®] and Belotero[®]. Hyalorm[®], derived from rooster coombs; Captique[®], a plant-based HA; Eleveess[®]; and Prevelle Silk[®] are other approved agents no longer sold in the United States.^{3,5} The FDA has also approved two longer-acting agents (poly-L-lactic acid [Sculptra[®]] and calcium hydroxylapatite [Radiesse[®]]), as well as one permanent filler, polymethylmethacrylate (PMMA) (Bellafill[®], formerly marketed as Artefill[®]).²

GENERAL INJECTION TECHNIQUE

Consultation

Major goals of the initial consultation are baseline evaluation, understanding of relevant medical history, and patient education. The dermatologic surgeon must evaluate the type, location, depth, and diameter of the deficit, as well as the quality of the surrounding tissue, which may alter the final appearance of augmentation. Appreciating the etiology of cutaneous defects will help select the most appropriate therapeutic modality and tailor the treatment plan accordingly. Distinction should be made between static and dynamic rhytides (the latter are usually more amenable to chemodenervation) and between changes as a result of chronologic age compared to solar damage ([Table 58-1](#)). Patients should be evaluated in a seated or gravity-dependent position with ample lighting streaming from an acute angle that highlights subtleties. This careful positioning allows for better selection of the filler product and injection technique. Standardized, before-and-after photography is strongly recommended to track changes over time and help explain procedures.

Table 58-1. Etiology of Cutaneous Defects and Deficits

Etiology	Description
Chronologic age	■ Gravity-related tissue descent and sagging ■ Loss of subcutaneous fat ■ Bone resorption
Photodamage	■ Pigmentary alterations (i.e., solar lentigines, melasma) ■ Rhytides from decreased extracellular matrix turnover and degradation ■ Neoplasia
Scarring	■ Acne ■ Varicella zoster ■ Surgery ■ Trauma ■ Other
Inflammation	■ Infection- or medication-related lipoatrophy or wasting (i.e., HIV) ■ Collagen vascular disease (i.e., linear morphea, Parry–Romberg disease, lupus, other)
Other	■ Congenital lipoatrophy ■ Medication side effects (i.e., antiviral therapy) ■ Exercise-induced lipoatrophy and gravity-related changes ■ Nutritional deficiencies ■ Idiopathic lipoatrophy

HIV, human immunodeficiency virus.

Appropriate patient selection is key in ensuring good outcomes, and involves taking a detailed past medical history. [Table 58-2](#) outlines some helpful medical information to determine which patients are candidates for soft-tissue augmentation and which products may be most suitable for them. A history of prior allergic reaction to the filler material or its constituents (i.e., amide anesthetics such as lidocaine, or—for some HA fillers—gram-

positive bacterial proteins) is a major contraindication. Intervention should be postponed for infections or inflammation in the treatment area. Care should be taken in those with bleeding disorders, and all nonessential anticoagulation and/or antiplatelet medications may be held to limit the risk of ecchymosis. If used only as needed for pain, patients may discontinue aspirin 10 to 14 days and nonsteroidal anti-inflammatory agents (NSAIDs) 5 to 7 days prior to the procedure. There are many other over-the-counter supplements that may increase bleeding and bruising, such as omega-3 fatty acids/fish oil, garlic, ginseng, ginkgo biloba, St. John’s wort, and high-dose vitamin E, so these too should be temporarily stopped.^{2,5}

Table 58-2. Preprocedure Evaluation and Consultation Considerations

Patient goals and expectations	■ Defect(s) of concern ■ Expected outcomes ■ Expected duration of correction ■ Acceptable recuperation time/downtime
Medical history	■ Past medical history (i.e., infectious disease, collagen vascular disease, granulomatous disease, scarring condition including propensity for keloids) ■ History and location of herpes simplex viral infection ■ Past facial surgery (i.e., facelifts, reconstruction) ■ Past rejuvenation procedures (i.e., injections, implants) ■ History of hypersensitivity reaction to filler products or their constituents ■ Medications, particularly anticoagulant and antiplatelet agents ■ Current or anticipated pregnancy/lactation
Defect assessment	■ Anatomic location ■ Type (i.e., superficial, medium, or deep folds and wrinkles; volume loss; localized or global lipoatrophy) ■ Volume of product necessary for correction ■ Quality of adjacent skin ■ Benefits, risks, alternative, or complementary treatments

Patient education is another critical component of the consultation. Surgeons should inquire about subjective deficits and teach about the relevant anatomy contributing to these “problem” areas. There should be a frank discussion about the indications, benefits, limitations, risks, and alternatives of soft-tissue augmentation, including surgery, resurfacing, neuromodulation, and no intervention. The anticipated duration of results; need for repeat treatments in the future; estimated financial costs; and post-procedural recovery should be emphasized. In the end, the overall success and satisfaction relies on setting and achieving clear, realistic expectations.^{2,5}

Preprocedure

After thorough evaluation and discussion, written consent should be obtained, and the skin sterilized with isopropyl alcohol, chlorhexidine, or equivalent agent.⁶ Clean technique from the start to finish helps prevent contamination and seeding of the implant. This should be adhered to when handling, mixing, injecting the filler, and prepping the skin as well. Gloves should be changed after contact with the oral mucosa.

Anesthesia to decrease discomfort from injections is another component of many treatment protocols. Some newer agents (i.e., Restylane, Perlane, Juvederm, Bellafill/Artefill) come premixed with lidocaine, while others require physicians to compound their own off-label (Table 58-3). Cryoanesthesia with ice or commercial devices and topical anesthetic preparations, such as benzocaine, lidocaine, prilocaine, and/or tetracaine, are other common adjunctive methods. Less often, nerve blocks or regional anesthesia can be used to limit pain associated with injections.

Table 58-3. FDA-Approved Soft-Tissue Fillers in the United States

No Longer Available in the United States ^a	Available in the United States
Bovine-derived collagen Zyderm I, Zyderm II, Zylplast	Non-animal-stabilized hyaluronic acid ■ Restylane/Restylane-L^b, Perlane/Perlane-L^b ■ Juvederm Ultra/Juvederm Ultra XC^b, Juvederm Ultra Plus/Juvederm Ultra Plus XC^b ■ Belotero balance ■ Juvederm Voluma XC
Porcine-derived collagen Evolence ^c	Synthetic^c ■ Poly-L-Lactic Acid (Sculptra/Sculptra Aesthetic) ■ Calcium hydroxylapatite (Radiesse) ■ Polymethylmethacrylate (Bellafill/Artefill)
Non-cadaveric human collagen CosmoDerm [®] 1, CosmoDerm 2, CosmoPlast [®]	Autologous ■ Autologous fat ■ Autologous fibroblast therapy (Azticel-T/laViv)
Cadaveric human collagen Dermalogen [®] , Cymetra [®]	
Avian-derived hyaluronic acid Hylaform [®] , Hylaform Plus	
Non-animal stabilized hyaluronic acid Captique, Eleveess, Prevells Silk [®]	
Autologous fibroblast therapy Autologen, Fibrel, Isolagen	

^aProduction suspended because of voluntary manufacturer discontinuation or decreased demand in favor of other products.

^bContains lidocaine.

^cSilicone injected off-label for soft-tissue augmentation.

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Injection techniques

There are multiple acceptable injection techniques, and selecting the most appropriate is often a question of provider preference and experience. Some anatomic locations and fillers are more amenable to particular techniques as described below.⁶

- *Serial puncture technique*: Small aliquots of filler are injected close together so that they integrate continuously along a rhytid or fold. Post-injection massage further facilitates this blending.
- *Linear threading technique*: The full length of the needle is introduced dermally or subcutaneously, and filler injected linearly either retrograde (as the needle is withdrawn) or anterograde (as the needle is inserted), which creates a plane of blunt dissection.
- *Cross-hatching or radial injection technique*: Regularly spaced, linear threads created by injecting in more than one direction to form a grid pattern.
- *Fanning technique*: The needle is inserted at a single site then passed multiple times in different directions without fully withdrawing the tip from the skin.
- *Depot injection techniques*: Boluses of filler are injected along the periosteum, usually to correct volume deficiency in the temporal, zygomatic cheek, and chin areas. Postprocedural massage helps prevent nodularity and smooth contour irregularities.

Historically, augmentation focused on directly filling folds, but there is now an emphasis on facial volumizing to replace the soft tissue and bone loss that occurs with age or photodamage. Furthermore, this volumizing effect indirectly smoothens wrinkles and fine lines.⁷

Pertinent vascular anatomy

In addition to knowledge of multiple injection techniques, expert practitioners should have a detailed grasp of relevant vascular anatomy in an attempt to avoid devastating adverse events. This has been investigated in detail in the past,⁸ and some of the most high-risk and frequently discussed regions are addressed in [Figure 58-1](#).

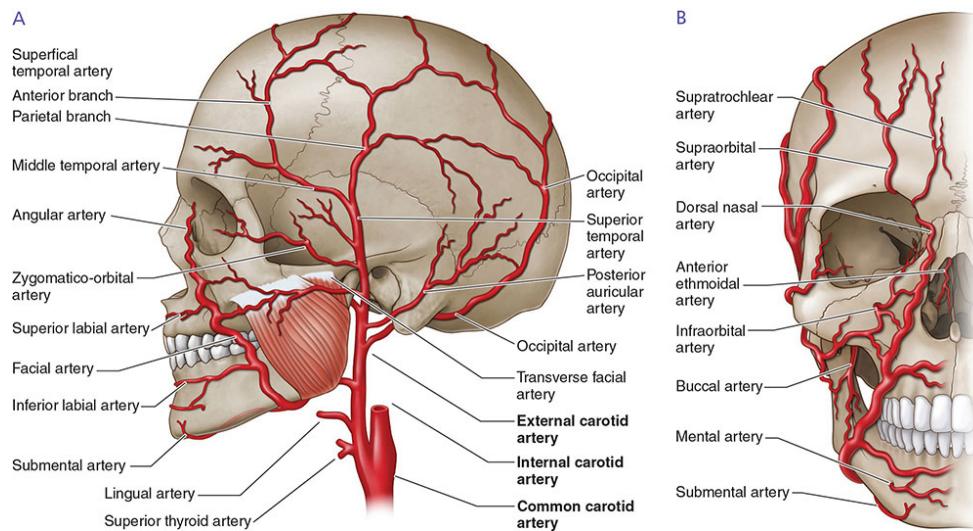


Figure 58-1. Anastomoses of the internal and external carotid circulations.

The majority of facial blood supply comes from branches of the external carotid artery, which anastomose with divisions off the internal carotid artery at the nose. The facial artery is the most studied and frequently compromised branch of the external carotid. It extends along the mandible up toward the medial canthus under the platysma, zygomaticus major, and lip elevator muscles to terminate in the angular artery that runs along the lateral nose. These landmarks are general guidelines, however, and the path is tortuous with substantial individual variation,^{9,10} so care must be taken when injecting at the medial cheek and along the nasal sidewall because there is a higher risk of arterial occlusion. Blunt-tip cannulas that do not pierce vessel walls as easily as needles may be safer in these regions, though this has yet to be definitively established.

The angular artery supplies the nasal sidewall before joining with the dorsal nasal artery, one of two divisions of the ophthalmic artery, at the root of the nose. The latter continues down the nose, irrigating its root and dorsum, before anastomosing with the lateral nasal artery, a branch of the facial artery. There have been reports of retrograde emboli and blindness due to these interconnection and again, care must be taken to inject small aliquots under low pressure periosteally and perichondrally along the nose.

Similarly, anastomoses between the cutaneous and ophthalmic circulation in the upper face may lead to blindness and even cerebrovascular deficits. Both the supraorbital and supratrochlear arteries branch off the internal

carotid near the glabella. The supraorbital emerges from the supraorbital notch just medial to the mid-pupillary line, while the supratrochlear lies beneath the medial most glabellar rhytid. They run along the bone for approximately 1 cm, then pierce the frontalis muscle and branch superficially. Hence, injections at the medial portion of the upper face should only be performed with cannula or superficially in the dermis, while those in the mid-to-upper portion of the forehead should be periosteal deep to the level of the vasculature. As with the dorsal nose, complications occur from direct injection into or compression of the vessels or retrograde emboli into the ophthalmic and then terminal retinal arteries off the internal carotid.

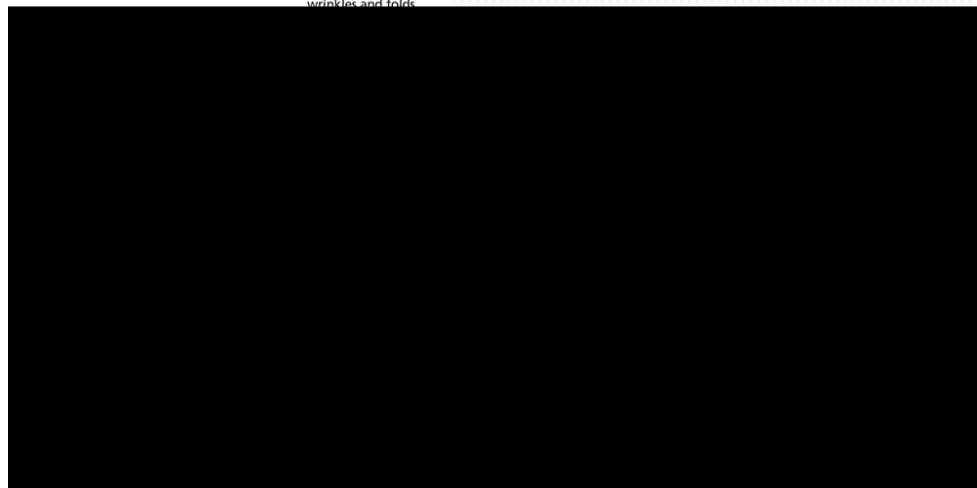
INJECTABLE SOFT-TISSUE FILLER MATERIALS

Filler selection

The number of available filler materials for soft-tissue augmentation and rejuvenation continues to increase.³ They can be categorized based on different qualities: derivation (autologous, xenograft, allograft, synthetic, semi-synthetic); depth of cutaneous injection (dermal, subcutaneous); reversibility (reversible and nonreversible); and longevity (temporary and permanent). [Table 58-4](#) compares selected FDA-approved agents. Knowledge of these different properties allows for appropriate placement at the appropriate anatomic location.

Table 58-4. Important Properties of Soft-Tissue Fillers

Filler Trade Name (®, TM)	Major Materials	FDA Indication(s) ^b	Availability	Longevity	Skin Testing	Reversible	Unique Features
Zyderm 1911, Zyplast	Bovine-derived collagen (98% purified type I in phosphate-buffered saline, 0.3% lidocaine)	Dermal injection for soft-tissue contour irregularities	No longer in the United States	3–6 mo	Yes	No	■ Zyplast cross-linked with glutaraldehyde—less immunogenic and longer-lasting ■ Lip augmentation most common application ■ Hypersensitivity 3%
Evolve	Porcine-derived collagen (type I collagen cross-linked with ribose sugar)	Dermal injection for moderate to severe facial wrinkles and folds such as nasolabial folds	No longer in the United States	Up to 1 year	No	No	■ Less immunogenic than bovine collagen ■ Avoid lip enhancement; risk of nodule formation
CosmoDerm 1/2, CosmoPlast	Human bioengineered collagen (single human fibroblast cell line, tested for disease)	Papillary dermal injection for soft-tissue contour deficiencies such as wrinkles, acne scars	No longer in the United States	3–6 months	No	No	■ Similar properties to bovine collagen except no risk of hypersensitivity
Fascian	Cadaveric fascia lata	Marketed in accordance with Tissue Reference Group (TRG) criteria rather than as a device, no prescribed indications. Grafts applicable to subdermal correction at any anatomic location	No longer in the United States	Up to 8 months	No	No	■ Highly biocompatible ■ Requires large-bore needle for pretunneling or subcision ■ Trace amounts of polymyxin sulfate, bacitracin, gentamycin, avoid if history of allergy ■ Substantial postprocedural edema
Restylane/Restylane-L/ Restylane Silk Perlane/Perlane-L	Bacterial-derived hyaluronic acid	Dermal injection for: (1) Moderate to severe facial wrinkles and folds (2) Lip augmentation in adults (Restylane-L and Silk only)	Yes	6–9 months	No	Yes	■ Highly biocompatible ■ Rare risk of hypersensitivity ■ Room temperature storage, biodegradable, long shelf life ■ Reversible with off-label hyaluronidase (Vitrase, Hylenex) degradation
Belotero balance	Bacterial-derived hyaluronic acid	Dermal injection for moderate to severe wrinkles and folds	Yes	6–9 months	No	Yes	See Restylane
Juvederm Ultra/ Juvederm Ultra XC Juvederm Ultra Plus/ Juvederm Ultra Plus XC	Bacterial-derived hyaluronic acid	Dermal injection for moderate to severe facial wrinkles and folds	Yes	6–9 months	No	Yes	See Restylane
Juvederm Voluma XC	Bacterial-derived hyaluronic acid	Subcutaneous or supraperiosteal injection for age-related volume loss in the midface in adults over 21 years	Yes	Up to 24 months	No	No	■ Higher-risk delayed nodularity compared to other HA derivatives
Hylaform, Hylaform Plus	Hyaluronic acid from rooster combs	Dermal injection for moderate to deep wrinkles and folds	No	6–9 months	No	Yes	See Restylane



(Vicryl®) suture material, and must be reconstituted with sterile water or saline into a suspension for injection.

First developed and marketed in Europe as New-Fill®, Sculptra gained FDA approval for treatment of HIV-related facial lipoatrophy in 2004. In 2009, the FDA-approved Sculptra Aesthetic for shallow-to-deep wrinkles, including the nasolabial folds, in immunocompetent patients. Panfacial injections are an off-label option in patients with limited volume loss. Sculptra is typically injected with 25- or 26-gauge needles serially or as depots into the subcutaneous plane. More superficial deposition increases the risk of visible nodules. After injection, immediate correction is the result of edema and solvent from the solution, which dissipates. Persistent augmentation takes longer to appear and requires three or more treatment sessions, spaced every 3 to 6 weeks.²⁸

Preparation and storage practices vary among practitioners. Current packaging suggests reconstituting each vial with 4-mL sterile water and 1-mL lidocaine just 2 hours before use. However, the resultant 5 mL of solution is thick and can clog syringes or more readily form papulonodules, so most clinicians prepare their mixture with as much as 8 to 11 mL of sterile water at >24 hours.²⁷ Agitating the vial and/or syringe also helps maintain particles in solution. Nonetheless, frequent needles changes or back aspiration may be needed if the product precipitates.

Though not unique to this filler, formation of delayed-onset papules, nodules, or granulomatous reactions at the site of injection are important adverse effects after Sculptra (Fig. 58-7). In the phase 3 extension study, these complications occurred in 17.8% (20/116 patients) of treated compared to 12.8% (15/117 patients) of control sites and appeared months later, often persisting for more than a year.²⁹ Reconstituting the solution farther in advance, diluting with larger volumes, injecting into the subcutis rather than the dermis, administering smaller aliquots, and massaging treatment sites postprocedurally are strategies used to prevent papulonodule formation. In fact, massaging should continue at home in accordance with the “Rule of 5’s:” 5 minutes, 5 times per day for 5 days. No controlled studies to date have determined whether this technique truly limits the development of delayed reactions.

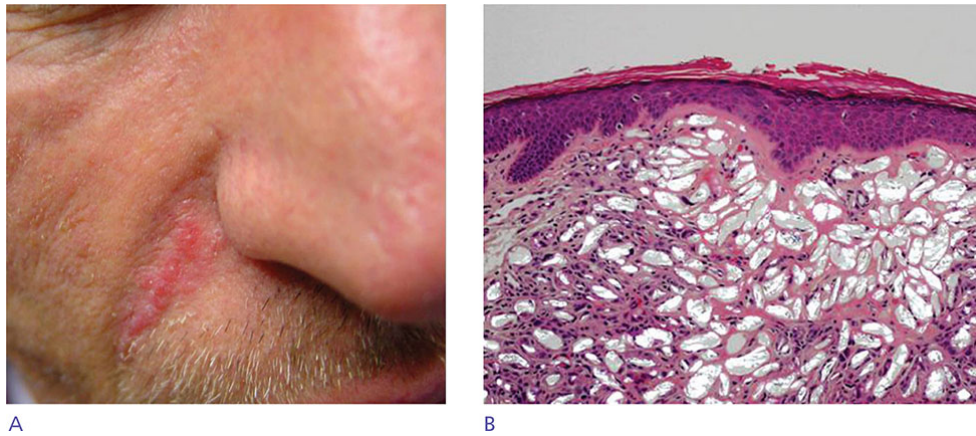


Figure 58-7. Granulomatous papules after intradermal Sculptra injection. Clinical image (A) and histopathology stained for hematoxylin and eosin (H&E) (B).

Calcium hydroxyapatite

Calcium hydroxyapatite has been marketed in the United States under the name Radiesse since 2006. It is a semi-solid suspension of 25- to 45- μ m calcium hydroxyapatite microspheres in a gel carrier of sterile water, glycerin, and sodium carboxymethylcellulose. The primary mineral component of these spheres is the same as the calcium phosphate in bone and teeth, so the filler is biocompatible with low risk of allergic reaction. Mechanistically, new collagen forms over the calcium hydroxyapatite framework and replaces the carrier solution. These effects have been documented histologically for nearly 20 months, although clinical results beyond 12 months are less clear.⁷

On-label applications of Radiesse include correction of: (1) moderate to severe facial folds and wrinkles such as the nasolabial folds (2) lipoatrophy associated with HIV; and (3) volume loss of the dorsal hands, an often overlooked area that shares the same photo- and age-related volume changes as the face.^{27,30,31} Facial revolumizing in immunocompetent patients is an off-label indication.^{7,32} (Fig. 58-8); Radiesse should be injected at the dermal subcutaneous junction or over periosteum. Results are immediate, with correction persisting for about 12 months. It should not be used for lip augmentation due to the risk of granuloma formation and with care around the mouth, where constant contraction of the orbicularis oris during phonation may lead to migration and beading of the filler.³² Because of substantial pain

and throbbing after injection, the FDA allows for premixing of Radiesse with 2% lidocaine before treatment.

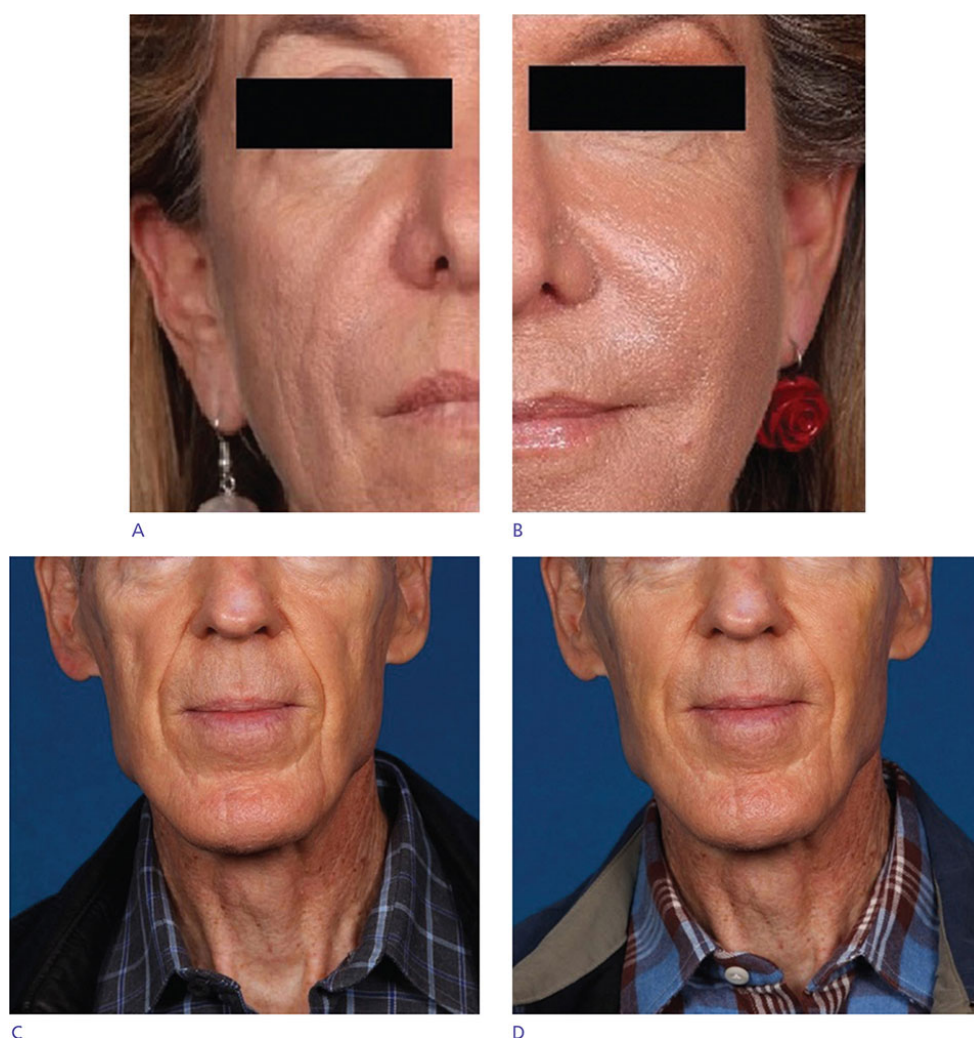


Figure 58-8. Treatment with Radiesse at the nasolabial folds (baseline A, after B) and midface (baseline C, after D) in immunocompetent patients.

Of note, patients should understand that while Radiesse is radio-opaque and may be visible on radiographs, CT scans, and mammograms, the filler has not been shown to limit interpretation or obscure findings.³³

Polymethylmethacrylate

Bellafill, formerly marketed as Artefill in the United States, is a solution of PMMA beads in 3.5% bovine collagen and 0.3% lidocaine with sterile

water, phosphate buffer, and sodium chloride. The 30- to 50- μm microspheres are nonabsorbable and inert, made of the same compound as acrylic glass (trade names PlexiglassTM, LuciteTM, and PerspexTM) or in orthopedic bone cement and intraocular lens implants for cataract surgery. The collagen in Bellafill/Artefill acts as a fluid carrier that degrades over 1 to 3 months and leaves intact beads, which become encapsulated in endogenous collagen.^{27,34}

In 2006, Bellafill/Artefill became the first and only FDA-approved permanent filler available for correction of the nasolabial folds.³⁵ In 2015, it gained an indication for treatment of moderate to severe, distensible, atrophic acne scars in those over age 21 years. Skin testing for hypersensitivity reaction to the bovine collagen component is necessary before augmentation.

Unlike its predecessors, Arteplast[®] and Artecoll[®], Bellafill/Artefill has a lower rate of inflammatory adverse reactions, because the PMMA particles are more spherical, smooth, and uniformly sized. The manufacturer eliminated smaller microspheres measuring <20 μm , which are readily phagocytosed and cause granulomas.

A 5-year follow-up analysis of patients on the Bellafill/Artefill FDA pivotal nasolabial folds trial found that most were satisfied or very satisfied (95% and 83%, respectively) with their long-term results. Only 2% reported delayed adverse events, including irregular contour or granuloma formation, most of which were treatable.³⁶ Seventy-seven percent of participants in the acne scarring phase 3 trial reported improvement at 6 months compared to 44% of controls; these results persisted up to 1 year of follow-up. There were no delayed granulomas noted in the latter study. The authors do not recommend injecting this product off-label in large quantities for volumizing, where there is a greater incidence of severe, recurrent subcutaneous inflammation and induration.³⁷

Autologous fibroblasts

The FDA-licensed Azficel-T (laViv[®]) in 2011 as a biologic product for the correction of moderate to severe nasolabial folds. Preparation of the material requires isolation and culture of autologous fibroblasts from punch biopsies of posterior auricular skin. These specimens are sent to the manufacturer who

grows the cells in vitro until there is 1.2 mL of suspension containing 18 million patient-specific fibroblasts in Dulbecco's Modified Eagle's Medium (DMEM). In the pivotal phase 3 trial, there was a statistically significant improvement in the appearance of nasolabial folds at 6 months versus placebo. Efficacy beyond that length of time is less well established.³⁸

Drawbacks of Azficel-T compared to other fillers include requisite skin biopsies, producing secondary defects and scars; delay between time of specimen collection and fibroblast injection; unclear duration of correction; limited yield based on volume and quality of biopsy tissue sent; and high cost. Hence, several other products (i.e., Autologen[®], Fibrel[®], Isolagen[®]) derived from autologous fibroblasts are no longer sold in the United States.

Fat grafting

Some consider autologous fat the optimal filler, since it is relatively abundant, highly biocompatible, able to provide natural-appearing volumetric correction, and potentially permanent, although rates of graft survival are variable.³⁹ The concept of fat transfer is not new. However, older en bloc techniques required excision of a solid section of tissue with subsequent implantation in larger segments, a process that left not only a new donor-site defect but also possible graft-site incisional scars. The advent and popularity of liposuction in the 1980s made lipotransfer more feasible. Aspirated fat could be reinjected through small-bore cannulas or needles with minimal scarring.^{40,41}

Deficits at the nasolabial folds, cheeks, marionette lines, lips, infraorbital region, as well as atrophic scars (i.e., those from acne) and areas of stable, subcutaneous, facial atrophy (i.e., from linear morphea or Parry-Romberg syndrome) may all be improved with autologous fat transfer. Correction of HIV-related lipoatrophy and rejuvenation of the dorsal hands are other documented indications. Lipotransfer is unable to treat fine lines or small, superficial scars that require dermal placement of filler.⁴²⁻⁴⁴

There are multiple modalities for harvesting, processing, and injecting fat.^{45,46} No studies to date have established an optimal donor site, and any region of excess adipose may be reasonable. Common sites are readily accessible, insensitive to weight loss via diet and exercise, and associated with low morbidity: periumbilical, lumbar back, trochanteric buttocks and/or

medial thigh, and medial knee or arm.⁴⁷ Common harvesting practices involve pre-medicating patients with anxiolytic and/or narcotic drugs as needed, infiltrating the subcutaneous space at the donor site with tumescent anesthesia, consisting of saline admixed with small amounts of lidocaine with epinephrine, and making small incisions. A traditional aspiration cannula or 14-gauge single-holed microcannula attached to a hypodermic Luer-Lok[®] syringe can be used to harvest the fat. Graft survival is directly related to graft trauma, and care must be taken to maintain suction at less than 1 atmosphere (i.e., by using small syringes). Increased suction vaporizes and breaks adipocytes.³⁹ Gravity layers out the supernatant fat, so it can be washed of oils, blood/serum, and anesthetic fluid. Kuran et al. reported good success with open system purification,⁴⁸ but this technique may increase the risk of infection. Centrifuge separation is also an option; however, resultant trauma may decrease graft survival.^{49,50} Extracted adipose can be frozen at –30°C (slow freezing, slow thawing process) and stored for as long as 12 to 18 months.⁵¹ There are also several ways to place the fat grafts. Fat is deposited with a large-bore 16- or 18-gauge needle or cannula parallel to the target rhytides. Alternative methods include pearl fat grafting or microautologous fat transplantation (MAFT).^{40,48}

Postinjection massage helps mold and distribute the grafts evenly. Unlike Sculptra, patients should not continue this massaging at home, and should avoid dynamic facial animation, since the motion may encourage graft migration. Systemic antibiotics and aspirin/NSAID-free pain management regimens are other frequent postoperative practices. Patients should be counseled about edema that may last for weeks.

Determining the degree and longevity of graft survival has proven difficult and unpredictable.^{45,46,52} Outcomes depend on technique and experience, with new methods showing up to 50% long-term success.³⁹ In general, repeated, small volume injections every 3 months are better than large volume augmentation. If the graft is too big, then passive diffusion from the recipient bed may not sufficiently maintain its metabolic demand and revascularization is insufficient. Overcorrection anticipates some graft loss but increases the rate of failure and even necrosis. Graft migration occurs with overfilling as well—moving to areas with less tension or better blood supply.

Although there have been many developments in the field of lipotransfer, questions persist. Patients should thoroughly understand the strengths and limitations, in particular the need for two procedures (harvesting and implantation) and multiple sessions, as well as likely downtime.^{34,53}

Silicone

Injection of silicone (polydimethylsiloxane, PDMS) has a storied past, and its use as a soft-tissue implant continues to be controversial. The term silicone refers to a family of inert, silicon-containing synthetics. Siloxanes are members of this family, composed of silicon, oxygen, and methane. For any given compound, the siloxane chain length and polymerization determines its viscosity, measured in centistokes (cs). The viscosity of water equals 1 cs and 350 cs for mineral oil. Heavy metals, oils, and other organic substances naturally contaminate silicones, so purification is compulsory. Proponents of silicone injection for augmentation believe that many of the reported adverse reactions result from impurities and that it is safe and effective in the hands of experienced providers who administer small quantities of product.

Permanent augmentation with PDMS became popular in the 1960s with the introduction of medical grade products. Soon, untrained practitioners began injecting industrial silicones or adulterated oils instead, which caused severe complications. Medical grade liquid injectable silicone has a viscosity of 350 cs and is purer than industrial compounds. Despite clinical trials, it was never FDA-approved for use in humans. AdatoSil[®] (5000 cs) and Silikon[®] (1000 cs) were approved in 1994 and 1997, respectively, for ophthalmologic indications and have been injected lawfully for soft-tissue augmentation since 1997, when the FDA passed the Modernization Act allowing off-label use of medical devices. Silikon 1000 is currently the most appropriate agent available.

The technique is paramount when administering permanent fillers. The microdroplet serial puncture method allows for more precise placement: 0.005 to 0.01 mL aliquots deposited every 2 to 5 mm subdermally (Fig. 58-9). Overcorrection or multiple passes should be avoided. Relatively small volumes are recommended, and in a given treatment session, no more than 0.5 mL should be used for regions with small surface area defects (i.e., the

nasolabial folds), and up to 2.0 mL may be used for regions with large surface area defects (i.e., facial lipoatrophy). These volumes decrease over time as the desired effect is achieved. Treatment sessions typically occur every four weeks initially and then can be spaced farther apart to allow sufficient time for fibroplasia to encapsulate the product.⁵⁴



Figure 58-9. Silicone correction in a patient with human immunodeficiency virus (HIV).

Risks related to silicone augmentation are real but often secondary to improper technique, incorrect dosage, or tainted material. Erythema, edema, and ecchymoses are common and usually resolve within days. Dermal, instead of subdermal, injection can cause rippling. Other potential complications include superficial beading from overcorrection, granuloma formation (Fig. 58-10), and product migration, which is more likely with large amounts of less viscous oil. Meticulous treatment protocols frequently help avoid these adverse events,⁵⁵ yet delayed granulomatous reactions weeks, months, or years after treatment are possible and may require intralesional corticosteroids combined with 5-fluorouracil, and possibly systemic antibiotics.



Figure 58-10. Nodule formation after silicone injection.

Amid decades of debate, recent studies suggest that when injected under optimal conditions, the complication rate from silicone soft-tissue augmentation is less than 1%. In expert hands, highly purified injectable silicone is a reliable and reproducible option for correction of advanced HIV-associated lipoatrophy.^{27,56}

COMPLICATIONS

Given that facial rejuvenation is largely an elective procedure, the safety of soft-tissue fillers is paramount. Significant adverse events are infrequent. Possible complications and methods of addressing them are listed in [Table 58-6](#).

Table 58-6. Complications from Soft-Tissue Fillers

Complication	Description	Prevention and Management Considerations
Injection site reactions	Generally mild and resolves in 1 week ■ Erythema ■ Edema ■ Induration ■ Pain ■ Bleeding ■ Bruising	■ Prevention ■ Hold anticoagulant/antiplatelet agents (i.e., aspirin) if possible ■ Pretreat with local anesthetics for pain ■ Inject with small-bore needles ■ Use cannulas or fewer injection sites to limit the number of punctures and bruising ■ Avoid rigorous physical activity for 24 hours postprocedure ■ Management ■ Apply ice for edema and pain ■ Treat bruises with intense pulse light or vascular lasers
Nodules, beading, and Tyndall effect	■ Superficial injection ■ Bluish discoloration (Tyndall effect) with particulate HA derivatives	■ Prevention ■ Avoid superficial deposition ■ Inject smoothly and regularly without large blebs of product ■ Management ■ Massage ■ Inject hyaluronidase if HA filler ■ Aspirate, excise
Persistent papules	■ Higher rates with specific products	■ Sculptra: increase dilution volume, dilute farther in advance of procedure, agitate solution vigorously ■ Radiesse: avoid injections around mouth due to migration from phonation ■ Bellafill/Artefill: inject smoothly ■ Silicone: use microdroplet technique
Infection	■ Acute bacterial (cellulitis, abscess)	■ Prevention ■ Cleanse with antimicrobial agent (i.e., alcohol, chlorhexidine) ■ Wear clean gloves, switch after intraoral contact or injection ■ Inject smoothly and regularly without large clumps of product ■ Management ■ Start antibiotics ■ Culture and consider biopsy for histopathology ■ Incise and drain, if indicated
Herpes simplex virus reactivation	■ Perioral reactivation ■ Sites of prior facial infection	■ Prevention ■ Give prophylactic oral antiviral medication if history of postprocedural herpes, treating perioral region in patient with history of herpes labialis, or possibly, frequent recurrences ■ Delay injections if evidence of active outbreak ■ Management ■ Start full treatment dosing of oral antiviral medication
Hypersensitivity	■ Most common after bovine collagen fillers (up to 3%) ■ Rare with HA fillers from contaminants, by-products of bacterial fermentation, or lower-molecular-weight molecules; often resolves spontaneously	■ Prevention ■ Avoid injection if known sensitivity ■ Skin testing for fillers containing bovine collagen (i.e., Bellafill/Artefill) ■ Management ■ Consider starting tacrolimus ointment, intralesional corticosteroids ■ Incision and drainage
Delayed nodules	■ Inflammatory/immunologic ■ Biofilm ■ Infection (i.e., atypical mycobacteria) ■ Foreign-body granulomas	■ Prevention ■ Cleanse with antimicrobial agent (i.e., alcohol, chlorhexidine) ■ Skin testing before fillers containing bovine collagen (i.e., Bellafill/Artefill) ■ Management ■ Incise and drain with culture and/or biopsy for histopathology ■ Inject hyaluronidase if HA filler ■ Start broad-spectrum antibiotics for 2–6 weeks (i.e., clarithromycin, doxycycline/minocycline) ■ Consider starting topical, oral, or intralesional corticosteroids; intralesional 5-fluorouracil; oral immunosuppressants; laser therapy ■ Excise, if persistent
Vascular compromise	■ Necrosis (glabella, medial cheek) ■ Blindness, ophthalmoplegia (glabella, nasal dorsum, nasolabial folds) ■ Extremely rare, cerebrovascular accident	■ Prevention ■ Understand thoroughly facial anatomy, especially vascular anatomy ■ Understand thoroughly the depth at which different fillers should be placed ■ Inject small aliquots, slowly, under low pressure (limits retrograde embolization) ■ Use cannulas or small gauge needles in higher-risk regions ■ Management ■ Discontinue immediately for blanching, duskiness, reticulate erythema, severe pain, vision changes ■ Consider starting oral aspirin, prednisone, low-molecular-weight heparins, hyperbaric oxygen therapy ■ If ulceration/necrosis, provide careful wound care ■ In the setting of vascular compromise, apply warm compresses and nitroglycerin paste; massage; inject hyaluronidase along affected artery and its tributaries if HA filler

HA, hyaluronic acid.

Pain, erythema, edema, induration, bleeding, and bruising are the most common reactions. They are generally mild and resolve within 1 week. Intense physical activity that raises blood pressure may increase the incidence of ecchymoses and bleeding, so patients should abstain for 24 hours postprocedure. Limiting the number of needle sticks, using blunt-tipped cannulas or small gauge needles, slowly injecting small volumes of product, and temporarily holding unnecessary antiplatelet medications/supplements for the 7 to 10 days prior to treatment may help minimize these risks.⁵⁷ When

bruising does develop, energy based therapies (i.e., pulsed-dye or potassium titanyl phosphate lasers, intense pulsed light) may clear extravasated blood more rapidly.⁵⁸

In addition to injection site reactions, more serious complications occur at low rates. Intradermal placement can produce ridging, beading, and palpable or visible papulonodules. Superficial HA in particular can cause a temporary bluish tint in these areas due to the Tyndall effect—differential refraction of light off particles in a colloid (Fig. 58-11). Persistent papulonodules are more likely with Sculptra, Bellafill/Artefill, and silicone than other agents.

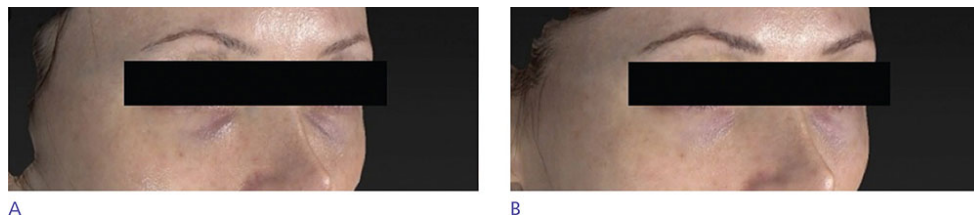


Figure 58-11. Tyndall effect at the tear troughs from superficial deposition of hyaluronic acid filler. Baseline (A) and after (B) hyaluronidase injection.

Infections, including cellulitis and abscesses, are another potential risk. Puncture sites can serve as portals of entry for resident skin or oral flora. Sterilizing the treatment area with isopropyl alcohol, chlorhexidine or another appropriate antiseptic and wearing clean gloves are common practice to minimize infection rates. All suspected infections should be cultured and/or biopsied for identification and sensitivities. Patients should start broad-spectrum antibiotics with or without anaerobic coverage until the results return.⁵⁹ Incision and drainage may be needed for fluctuant lesions. Injection-related trauma can also reactivate herpes simplex virus, particularly periorally. In those with a history of frequent or post-procedural outbreak(s), prophylactic antiviral therapy may be warranted, and injection should be delayed in the case of active blistering.⁵⁸

In the early era of soft-tissue augmentation, hypersensitivity reactions were far more frequent. Bovine collagen was the first FDA-approved soft-tissue filler in the United States, but 3% of patients developed antibodies and clinically significant allergy to the material.⁶⁰ Thus, skin testing was mandatory to decrease, albeit not fully prevent, this risk. In the United States, Bellafill/Artefill is the only currently marketed product still requiring skin

testing before augmentation. Part of the appeal of HA, Sculptra, and Radiesse is their biocompatibility, a quality that eliminates the need for preprocedural allergy testing. A few cases of hypersensitivity to HA do exist and may arise from contaminants, by-products of bacterial fermentation used in production, or lower-molecular-weight molecules such as those in Juvederm Voluma XC.^{59,61} While these reactions may subside spontaneously, topical calcineurin inhibitors, intralesional corticosteroid injections, systemic anti-inflammatory medications, incision and drainage, or hyaluronidase injection can hasten the process.⁵⁷

Both hypersensitivity and infection with or without biofilm can contribute to the formation of delayed nodules. Foreign-body reactions are another possible explanation, and distinguishing between these etiologies can be difficult. Unlike acute abscesses, biofilms lead to chronic infection. Microbial colonies adhere to the implant and secrete an extracellular polysaccharide matrix coating that is resistant to detergents, antimicrobials, and host immune responses. Clinically, nodules related to biofilms may appear inflammatory, infectious, abscess-like, or granulomatous.⁵⁹ Because conventional culturing methods frequently fail to detect the underlying bacteria, culture results may be misleading. Fluorescent in situ hybridization (FISH) detects the causative microbe in most culture-negative cases, but is not routinely run.⁶² Atypical mycobacteria can cause delayed infection as well, so separate histology and tissue cultures should be considered. Results from these studies should guide the ongoing treatment.

Any time a foreign body is introduced into the skin, there is potential for a nonallergic granulomatous reaction, even years after treatment. The incidence after HA correction has been reported as 0.02% to 0.4%.^{63,64} It is higher for non-HA materials.⁶³ As previously mentioned, volume injected, presence of impurities, and product type affects the rates of granuloma formation. HA and collagen typically develop cystic granulomas; silicone, paraffin, and polyacrylamide (not licensed in the United States) lipogranulomas; and PMMA and poly-L-lactic acid sclerosing granulomas.⁶³ Since differentiating inflammatory complications from biofilm infections is not straightforward, antibiotic treatment, such as clarithromycin or a tetracycline class medication for 2 to 6 weeks, rather than corticosteroids should be first line, and long-term antimicrobials may be prudent in suspect infections.⁶⁵

Fortunately, most contour irregularities, blue-gray discoloration, and acute and delayed nodules improve over time either spontaneously or with treatment. One of the appealing features of HA derivatives is the ability to reverse undesired outcomes with hyaluronidase (Fig. 58-12). There are two FDA-approved formulations, Vitrase and Hylenex, used off-label as first-line treatment to degrade injectable HA. Vitrase is a purified ovine testicular enzyme, while Hylenex is a recombinant human protein. The necessary hyaluronidase dose varies by formulation and filler. In vitro data suggest that more cross-linked HA derivatives require larger doses for optimal outcomes. It is reasonable to use 5 units of Vitrase hyaluronidase per 0.1-mL Restylane and 10 units per 0.1 mL of Juvederm.²⁶ Allergic reactions to hyaluronidase are rare, estimated at 1 in 2,000,⁶⁵ and the majority of these are localized. In nonemergent situations, intradermal skin testing may be considered, especially in patients with known allergies to bees, wasps, or hornets (classification order *Hymenoptera*), whose venom contains hyaluronidase. Those allergic to thiomersal are also at increased risk, since some enzyme formulations contain this preservative.⁶⁵ If intralesional hyaluronidase is ineffective or nodules occur in the setting of non-HA augmentation, other reported medical therapies include oral antibiotics (antimicrobial and anti-inflammatory effects); topical, intralesional, or systemic corticosteroids; intralesional 5-fluorouracil; oral immunosuppressants such as cyclosporine; lasers; or combination therapies.⁶⁶ Persistent or refractory nodules may require excision.



Figure 58-12. Correction of contour irregularities with hyaluronidase. Baseline (A) and after (B).

Though rare, potentially irreversible vascular complications are the most dreaded and serious adverse events following soft-tissue augmentation.⁶⁷ Vascular compromise from extravascular compression, intravascular injection, or embolism with downstream occlusion can cause tissue ischemia and necrosis. The glabella is a high-risk, watershed region due to limited collateral circulation.⁶⁸ Historically, up to 50% of patients treated with

Zyplast to the glabella developed some degree of necrosis.⁶⁹ Injection at the medial cheek similarly demands care.⁶⁸ The angular artery, a terminal branch of the external carotid, runs superior to the nasolabial fold then divides into the lateral nasal artery as well as other collateral branches that anastomose with the internal carotid system. Substantial anatomic variation in the exact course of these vessels exists. Moreover, the union of embryonic fusion planes at the alar groove prevents tissue distension, so there is little room to accommodate large quantities of filler without interrupting the vasculature.⁶⁷ Acute or excruciating pain, blanching, duskiness, and reticulate erythema (Fig. 58-13) tracking the involved artery and its tributaries may indicate impending necrosis. Typically, these signs occur immediately but can be delayed in the case of occlusion from postprocedural edema. Once recognized, treatment should begin immediately.⁵⁷ Prompt and ongoing care decreases the risk of permanent adverse effects and disfigurement.⁶⁷ One study recently reviewed several cases of vascular compromise and outlined treatment and prevention measures.⁶⁷ Because of its ability to decrease edema and consequently, external vessel compression, some recommend hyaluronidase injection irrespective of filler type.⁷⁰ Early reports supported infusion of up to 30 U of enzyme along the affected vasculature,⁷¹ but now the recommendation is to exceed 100 to 200 units.^{70,72,73} The more cross-linked the HA agent, the more hyaluronidase necessary for optimal outcomes.²⁶ Application of warm compresses and topical nitroglycerin, as well as firm massage, are other recommended treatments. Oral aspirin, prednisone, and hyperbaric oxygen, and low-molecular-weight heparins have been employed less frequently. Meticulous wound care is important if necrosis and ulceration do develop.



Figure 58-13. Evolving vascular compromise with dusky, reticulate erythema.

Alternatively, filler implanted intravascularly can embolize retrograde into the ocular circulation, a rare cause of ophthalmoplegia or blindness.⁷⁴ Incidence of this complication was reported as 0.001% in the past, but the largest recent review of cases performed by expert physicians found a rate of 0.05%. This increased rate may be partially attributable to the introduction of newer agents designed for deeper deposition.⁶⁷ Correction at the glabella, nasal dorsum, or nasolabial folds are at highest risk,⁷⁵ since branches of the internal carotid (i.e., supratrochlear and dorsal nasal arteries) either directly feed or anastomose at these anatomic locations. The internal carotid also gives rise to the ophthalmic artery and the central retinal artery; hence, injecting under high pressure can force product upstream into the ocular circulation⁷⁴ and produce sudden, profound pain and vision loss. More infrequently, forceful intra-arterial administration can cause cerebral artery embolism with potential infarct. Patients should undergo emergent ophthalmology and/or neurology evaluation if there is any concern for impairment; immediate retro- or peribulbar injection of at least 500 units hyaluronidase is one technique proposed to reverse partial vision changes.⁷⁶

Preventing vascular compromise is critical, considering that treatment of local tissue necrosis, blindness, or cerebrovascular infarct is often ineffective once it has occurred.⁷⁴ Using blunt-tipped cannulas instead of needles is one way to decrease potential risks. The cannula's flexible, dull end is less likely to pierce vessel walls and place fillers intralumenally. Cannulas may be especially prudent for subdermal injection at the central cheek medial to the mid-pupillary line.

Overall, facial rejuvenation with injectable fillers and implants is a safe procedure. Understanding regional anatomy, injection techniques, and methods to prevent and manage complications ensures successful outcomes.

CONCLUSIONS

As the demand for minimally invasive rejuvenation procedures climbs, so does the popularity of soft-tissue fillers to correct skin folds and subcutaneous volume loss. There has been an estimated 247% increase in the number of injections performed in the past decade and a half, second only to the increase in neuromodulator use.⁷⁷ The most desirable outcomes often come from combining different agents with different properties, and a strong understanding of the relevant anatomy, available products, injection techniques, potential complications, and realistic expectations ensures the best results for patients and physicians.

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CHAPTER 59 Ethnic and Gender Considerations in the Use of Facial Fillers

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SUMMARY

- As the popularity of fillers has increased dramatically over the past several years, appreciating the subtle differences in aesthetics between different sexes and racial backgrounds is of critical importance to the dermatologic surgeon in order to be able to effectively and prudently treat a diverse patient population.

Beginner Pearls



- Female temples should be convex, while male temples should be flat.
- While prominent lips are desirable in women, in men thinner lips are the norm, and therefore replacement rather than augmentation is desirable.

Expert Pearls



- When performing zygomatic augmentation, superior augmentation is performed in females, while inferior augmentation is performed in males.
- Although aging results in general bone loss of the facial skeleton, males experience this loss much later in life than women.
- The mid face is often one of the first areas to show signs of aging in African-American patients.

Don't Forget!



- A high G-prime volumizing filler such as calcium hydroxyapatite is an excellent choice to rejuvenate and aesthetically enhance a male face.
- When using calcium hydroxyapatite, consider transferring the product to a 1-cc syringe which allows for easier aspiration.

Pitfalls and Cautions



- Do not feminize the male face!
- Avoid adding volume to the anterior cheek in males.
- Replace rather than augment the male lip, and avoid the vermilion border.
- One of the worst pitfalls in aesthetic medicine is mistaking impending necrosis from intravascular injection for a common bruise and subsequently having the patient ice the area, further compromising blood flow.

Patient Education Points



- Instruct the patient to massage at home using the “rule of 5’s”—5 minutes, 5 times per day for 5 days.
- Patients should be instructed to immediately call the surgeon at the first sign of impending tissue necrosis.
- Taking a few minutes to explain facial aging may help patients better understand their options.
- Assess the degree of patient motivation before initiating a therapy plan.

CHAPTER 59 Ethnic and Gender Considerations in the Use of Facial Fillers

INTRODUCTION

Over the past decades, the use of facial fillers has increased dramatically. Among the fastest growing groups in the facial filler market include men and those with skin of color.¹ According to a study by the American Society of Aesthetic Plastic Surgery, ethnic minorities accounted for 22% of cosmetic procedures in the United States.² Moreover, as the ethnic minority population increases, this number is expected to grow accordingly. In order to best serve all patients, it is important to appreciate not only the role of ethnicity and gender in their care, but also the critical differences in ideal filler placement in different ethnic populations.

BACKGROUND

While the cosmetically undesirable signs of facial aging were initially believed to be secondary to the effects of gravity on the skin and subcutaneous fat (with treatments designed accordingly),^{3–6} there has been a paradigm shift over the past decade in understanding that the architectural changes of the aging face occur simultaneously in several tissue types: intrinsic and extrinsic skin changes, absorption of deep fat, and skeletal alterations.⁷ These changes of the skin, fat, and bone lead to changes in the

topography, shape, and proportions of the face, accounting for most of the visible changes of the aging face.⁸ Different ethnicities have subtle differences in these various compartments which may confer relative advantages or disadvantages in the visible signs of facial aging. For example, certain people inherit more fat cells in the deep fat compartments of the face, and others may have longer “internal clocks” on these fat cells. These people will appear to age better due to increased relative facial volume.⁹

An important factor in facial aging is the quality of the skin itself. Certain ethnic groups may have different facial pore size.¹⁰ Darker-pigmented individuals experience the benefit of less susceptibility to photoaging. Specifically, African-American skin has more melanin throughout the epidermis, which blocks ultraviolet (UV) radiation more effectively than Caucasian skin. African-American skin also tends to be thicker, with higher fibroblast activity.¹¹ Although these qualities drastically reduce the appearance of aging, they also make African-American patients more susceptible to postinflammatory hyperpigmentation, as well as keloid and hypertrophic scar formation. Accordingly, collagen-stimulating fillers tend to have a more profound effect on skin of color as long as there is no history of keloid formation.

Intrinsic aging of the skin is due to uncontrollable genetic influences, including ethnicity, anatomic variations, and hormonal changes in cutaneous tissues.¹² On the other hand, extrinsic skin aging is due to modifiable factors, such as lifestyle, smoking, and UV light exposure.¹² Both intrinsic and extrinsic aging affect the skin’s ability to adjust to underlying volume loss (deflation) and atrophy of the underlying skeleton and deep fat.^{13,14} Both intrinsic and extrinsic factors lead to destruction of the collagen matrix secondary to metalloproteinases.¹³ A decrease in extracellular collagen compromises the skin’s structural integrity and impairs fibroblast function.¹⁵ Unable to bind to degraded collagen, fibroblasts no longer receive the mechanical stimulus to induce the production of collagen, while production of collagenase increases.¹⁵ After age 30, these changes in collagen become more evident (Table 59-1).

Table 59-1. Causes of Facial Volume Loss

	Skin	Fat	Bone
Age of onset	20	40	50; later in males
Effect	Pore size, tired look	Gaunt, aged	Gaunt, aged
Approach to repair	Superficial fillers	Deep fillers	Deep fillers

Originally assumed to be a single confluent mass, facial fat is instead separated into discrete compartments.¹⁶ Each compartment ages independently of one another and may have subsequent effects on adjacent areas.¹³ The loss of deep fat creates the changes in shape, contour, and anterior projection associated with facial aging.¹³ Furthermore, the boundaries of the compartments are important determinants of facial anatomy.¹⁷ The deep medial fat boundaries, for example, determine the anatomical position of the cheek.¹⁷ Changes to deep fat begin around age 40 for most people, but may vary in certain individuals.

Although aging results in general bone loss of the facial skeleton, males experience this loss much later in life than women.¹⁸ Certain ethnicities also have more prominent facial bones, and will appear to age more slowly as they retain this crucial scaffolding. For example, Eastern European individuals tend to have smaller cheekbones, but they seem to look young for their age because the bone loss and remodeling happen very slowly. Furthermore, certain ethnicities such as Asians, African Americans, American Indians, Poles, and Russians have very pronounced cheekbones. They seem to age slower because they have more relative bone structure to start with. While they may develop a tired appearance over time, many signs of aging will be present years later when compared to Caucasians who have less prominent cheekbones.

Craniofacial bone remodeling can have an acquired cause or a genetic cause. For example bruxism, including teeth grinding, clenching, and temporomandibular joint disorders, leads to premature bone loss of the mandible, creating early aging around the mouth and jawline. This can be alleviated with the use of neurotoxins. Craniofacial bony remodeling is also a natural process that leads primarily to an enlargement of the orbital aperture and a decrease in the glabellar, pyriform, and maxillary angle.^{17–32} There is also a clockwise rotation of the maxilla and mandible when viewed in profile.³³ Gender differences have also been noted, with men having more acute angles in the upper face whereas women have more acute angles in the lower face.³³ There are also distinct gender-specific changes in the lower

face. As the chin moves retrograde in both genders, the lateral aspect of the mandible moves inward in women but outward in men. This craniofacial movement adds to the effects of menopause on bone loss and remodeling, which explains why women tend to have more signs of aging in the lower face than men.³⁴

Skeletal changes do not leave other aspects of the face untouched. The overall skeletal changes that occur with time shift the overlying soft tissue and ligaments of the face.¹⁴ With age, bony remodeling decreases space for soft tissue in the midface causing the soft tissue to fold in, known as the concertina effect.³⁵ Major changes in facial aging due to skeletal remodeling begin at age 50.³⁶

SEX DIFFERENCES

Whether male or female, all human faces begin as feminine.³⁷ Hormonal differences, namely testosterone, contribute to the development of male facial features.³⁷ Overall, men have a more square facial appearance attributable to flat, concave, and more angular features. Women have rounder, softer features leading to a more triangular face (Table 59-2).³⁸

Table 59-2. Key Sex Differences in Men and Women

	Female	Male
Temples	Convex	Flat
Lips	Pronounced-augment. Inject vermillion border	Thin-replace at most. Inject vermillion body
Zygoma	Superior augmentation	Inferior augmentation

Gender differences also vary based on location on the face. Upper facial features include the brow, the nose, supraorbital ridge, and associated muscles. Men have a straight brow that sits lower on the face, whereas women have an arched brow that sits higher on the face. The nose is slightly longer, and the fat compartments above the brows are very small in men. Men also have a more prominent supraorbital ridge, resulting in the appearance of deep-set eyes.³⁷ The corrugator is stronger in men and extends more laterally, while the frontalis muscle is larger and stronger.³⁸

Overall, the midface is wider in men than women. Although the zygomatic arch is more prominent in men, the midface is flatter, with more lateral cheek

projection and less anterior cheek projection. This is likely a function of women's relatively increased superficial fat compartments in the midface and cheeks. Men also have a more pronounced, angular jawline in the lower face while the chin is prominent, leading to a more square facial appearance. Women generally have a softer jawline, creating a more triangular face.³⁸

Men do not generally seek the oval face shape that women often pursue. Men enjoy some benefits in regards to aging of the face. Compared to women, the male facial skeleton retains its shape much longer with age.¹⁸ Special attention should be paid to key focus areas including the cheekbones, chin, and jawline.

The midface ages more slowly in men, and as the cheekbones recede the male cheek tends to move inferiorly and medially.³⁷ When placing facial filler in the male cheek it is important to avoid feminization. Practically, this means aiming to restore the cheek rather than augment it. The position of the male cheek apex is more medial and inferior relative to females. Facial fillers should be placed lower along the zygomatic arch and with less volume relative to female patients. Adding volume to the anterior compartment of the cheek should be avoided.

Men generally appreciate augmentation of the chin when necessary. A strong chin is a defining feature of the male face. Although both genders exhibit retrograde movement of the chin, the lateral aspect of the mandible moves inward in women but outward in men. Adding volume can enhance projection of a recessed chin in men.

Treatment of lips in male patients is often not desired or accepted. Males have thinner lips in general and this becomes more pronounced with age. If attempted, the focus of fillers in male lips should be restoration rather than augmentation. Filler placement should be concentrated at the vermillion body and not at the vermillion border.

Special attention should be paid toward sexual dimorphism in the temple and the zygoma. The temple is an important area for volumization in order to address aging. However, the youthful appearance of females derives from round and slightly convex temples. In contrast, males prefer straight and flat temples. Similarly, the focus of the zygoma in females is the superior aspect while in men the focus is slightly inferior.

Facial structure is not limited to gender influences only, but includes ethnic differences as well. Ethnicity therefore changes the goals of treatment

and the method by which those goals are achieved. Asians, Blacks, and Latinos tend to appear younger longer due to less skin aging and sagging compared to Caucasians.^{39–41} As previously discussed, the skin, fat, and craniofacial skeleton are the major foci for these differences.

ETHNIC DIFFERENCES

Patients of Asian ancestry

Asians have higher sun protection factor of the skin, providing better defense against photoaging.^{42–44} Wrinkles are less prominent due to an increased superficial fat and a thickened dermis.⁴⁵ Midfacial sagging is reduced secondary to increased fat and fibrous connection between superficial aponeuroses of the face and the deep fascia.⁴⁶

The overall structure of the Asian face is wide and short, creating a wider bitemporal, bizygomatic, and bigonial width compared to Caucasians.^{47–50} Although this skeletal width tends to form a more effective scaffolding to support tissue with age, female Asian patients may view a wide lower face as unfavorable. Asians also tend to have a flat profile, a result of the retraction of central midline skeletal structures.⁴⁶ The medial maxilla in particular is structurally lacking, creating evidence of volume loss in the infraorbital area even in younger patients.⁴⁶ The result is exaggerated dark circles and hollowing of the infraorbital area, which can be targeted with dermal fillers.⁴⁶ Ideally, an oval-shaped face is preferred for women in both Asian and Western countries.^{51,52} Asian women in particular strive toward an inverted egg-like shape.⁴⁶ That is, there is a preference toward a full upper half of the face with a narrowing transition from the cheek to the chin.⁴⁶

Given the delayed signs of aging, younger Asian females prioritize reshaping of the face.⁴⁶ The goal is not to appear Westernized, but to instead enhance the natural Asian features.⁴⁶ Facial injectables can assist in creating the “inverted egg” shape while creating three-dimensionality.⁴⁶ Neuromodulators reduce masseter hypertrophy, decreasing the width of the lower face which helps create a more ovoid facial shape.⁴⁶ Older Asians prioritize rejuvenation, using neuromodulators to address wrinkles, while

dermal fillers treat deflation particularly in the midface, nasolabial and perioral area, and jawline.⁴⁶ However, neuromodulators and dermal fillers not only rejuvenate, but address structural issues that arise secondary to deflation that occurs with aging.⁴⁶

Some of the common facial filler treatment areas in Asian patients include the midface (i.e., the nose, medial maxilla, tear trough, nasolabial fold), brow, and chin. Asians present with retraction of midline craniofacial structures, creating the defining characteristics of this ethnic group.⁴⁶ The midface is thus the primary area for dermal fillers to create three-dimensionality by increasing projection of these midline structures.⁴⁶ This may mean placement of filler to increase nasal projection, as Asians often request nasal augmentation.⁴⁶ Dermal fillers can further play a role in medial maxilla and chin augmentation to enhance anterior projection of the face.⁴⁶ When using facial fillers in the cheeks, usually more medial placement is preferred to aid in this projection as well as to restore volume in patients with loss of facial fat compartments.⁵² In addition, accentuating the superior border of the zygoma can reduce facial fullness. However, one must take careful note of the increased bizygomatic width of Asians, so as not to further exacerbate this feature with excess volume in the lateral half of the midface.⁴⁶ The medial maxilla should be the focus of treatment to compensate for structural deficits and prevent premature hollowing and dark circles.⁴⁶ Again, these treatments address both structural enhancement for younger patients and volume restoration in older patients.⁴⁶

The lower face in Asians has a tendency for bimaxillary protrusion.⁵³ This can make the chin appear relatively recessed. Implants or filler placement that increases mental protrusion may be desired. Lip augmentation or replacement should respect the ideal ratio of upper to lower lip vertical height of 1:1.3 in Asian lips.

As in African-American patients, Asian skin is more prone to pigmentation and keloid formation following procedures. Both ethnicities tend to have thicker skin with more pigment, fibroblasts, and collagen relative to Caucasian skin.⁵⁴ Care should be taken to avoid inflammation and bruising as much as possible. Avoiding serial puncture techniques with filler placement and being mindful of areas of the face prone to keloids such as the jawline can be helpful.

Patients of African ancestry

Although African-American patients enjoy several benefits in regards to aging of the facial skin, they often request facial fillers for specific concerns. A good principle for most patients is to restore their youthful looks rather than change their overall appearance. Special attention should be paid to key focus areas including the midface, lips, and neck.

The midface is often one of the first areas to show signs of aging in African-American patients. The smooth transition from periocular skin to malar skin becomes interrupted with age and produces a double convexity.⁵⁵ This shape is the result of several factors including loss of the malar bony eminence, loss of medial cheek fat, and the sagging of resilient, but thick and heavy skin. Practically, this leads to scleral show, infraorbital shadowing, and accentuation of the nasolabial folds. Placement of volumizing filler should be performed with the intent of correcting these changes if present.

Full lips are currently a sought-after feature by many patients. In contrast to Caucasian patients, African-American patients often enjoy full lips and do not require fillers for lip augmentation. With age, however, the lip volume that they previously enjoyed tends to fade. Patients may then seek filler treatment to restore the lip volume they originally had in youth. When treating the lips, a well-accepted ideal ratio of upper to lower lip vertical height is 1:1 for African-American lips. The vermilion border is rarely enhanced in African Americans although it is frequently treated in Caucasian females. African-American females have primarily volume loss of the upper lip while the lower lip usually retains its appearance.

The lower face and neck in African-American patients can sag and produce jowling with age. The skin retains its elasticity, however, can buckle under its own weight. Filler injections that globally aid in the support of superior structures may be of assistance. However, submental liposuction or other fat-directed therapy may be needed to address this issue.

Patients of Hispanic ancestry

Like Asian patients, features of Latino patients may include a wider face. They tend to have thicker and more sebaceous skin relative to Caucasians. They are spared from the level of wrinkling that Caucasian skin undergoes,

but like African patients, the heavy skin may tend to droop with loss of skeletal support and facial fat. In Latinos, this often results in lateral eyebrow drooping, pronounced nasolabial folds, and jowling.⁵⁶

Facial filler use in Latinos also requires addressing the midface. Similar to African-American patients, Latinos often lose the transition of periocular skin to malar skin and exhibit double convexity with aging. It may result in infraorbital shadowing and accentuation of the nasolabial folds. Proper placement of facial filler should support any skeletal or facial fat loss in this area. Lip augmentation or replacement should respect the ideal ratio of upper to lower lip vertical height of 1:1.3 in Latino lips with some individual variation, where the upper lip tends to be larger than the lower lip at rest.

The lower face and neck in Latino patients can produce significant jowling without wrinkling. Filler injections can help add support, however, submental liposuction or other fat-directed therapy may be needed as primary treatment.

Patients of Caucasian ancestry

Caucasian patients often suffer the worst degree of photoaging. Compared to other ethnicities, they exhibit more wrinkling of the skin and thinning of the skin. This is compounded by facial fat and bone loss. Facial filler use in Caucasians is often complemented by energy-directed therapies such as laser resurfacing or intense pulsed light to correct skin texture and pigmentation changes.

The Caucasian face tends to be narrower and longer. There also tends to be more projection of midline structures relative to other ethnicities. Midface filler is often placed more laterally along the zygoma and lateral maxilla relative to other groups.

Full lips are currently highly pursued by Caucasian female patients. In contrast to other ethnicities, Caucasian patients often have a thinner upper lip. With age, the lip volume decreases even further. Patients may seek filler treatment to restore their original lip volume or they may seek to augment their lips. A well-accepted ideal ratio of upper to lower lip vertical height is 1:1.618 for Caucasian lips.

TECHNIQUE

Introduction

A successful outcome with quality results starts with preparation and pretreatment considerations. Proper patient selection is of utmost importance. Patients with variable amounts of bone and fat loss who maintain some degree of skin elasticity are better candidates than those with a significant loss of elasticity. The latter may be better suited for surgical treatment. As with all invasive procedures, signed informed consent must be obtained. Review the contraindications and potential adverse events. Thoroughly discuss realistic expectations and anticipated downtime including likelihood of ecchymosis and edema. Take quality frontal, oblique, and lateral preprocedural photos with a solid colored background. Bring attention to any pre-existing asymmetries the patient may have. The patient should discontinue any nonessential medications that increase the risk of bleeding and ecchymosis.

Similar to other aesthetic products and procedures, the recommendations and methods regarding dermal filler use are constantly evolving. The authors recognize there is no single cookbook-type approach to facial rejuvenation and volumization. The recommendations herein reflect personal experiences and are meant to serve as a guide.

The majority of dermal filler techniques are similar regardless of ethnic background. Specific ethnic considerations and technique variation between African-American, Asian, Caucasian, and Latino individuals are discussed in detail. Basic strategies that accommodate these ethnic variations and allow the injector artistic freedom to address an individual patient's specific needs will deliver the best results.

Precise-Sculpt technique with poly-L-lactic acid

The variable dilution ratios, reconstitution times, injection techniques, and risk of nodule formation with poly-L-lactic acid (PLLA) can be intimidating to novice injectors and arduous at times to even experienced injectors. The 6-mL dilution technique (5-mL sterile water and 1 mL of plain 1% lidocaine) and increased reconstitution time (24–96 hours) minimize the risk of nodule formation without diminishing results.

Preparation

Twenty-four to 48 hours prior to the procedure, 5 mL of sterile water is injected into the freeze-dried vacuum sealed PLLA vial. Do not shake after adding the sterile water to avoid dry clumps from adhering to the wall of the vial. Ideally, a minimum of 24 to 30 hours should be allowed for reconstitution. On the day of the procedure add 1 mL of plain 1% lidocaine, bringing the total dilution to 6 mL. Gently agitate after adding the lidocaine and immediately prior to use until a uniform translucent suspension is obtained. Using a 1-mL syringe with Luer slip tip draw up 0.8 mL of the reconstituted PLLA with a 21-gauge needle. Drawing up 0.8 mL allows enough space in the syringe to create a vacuum when pulling back on the plunger to ensure the needle is not placed intravascularly. A total of 6 syringes should be prepared. Add 0.5 mL of lidocaine to the PLLA remaining in the bottle and draw up as a dilute 7th syringe. PLLA may then be injected using a 25-gauge needle.

A full single treatment typically requires 2 vials of PLLA, one for each side of the face, and therefore a total of 14 syringes should be prepared. The patient's face should be cleaned with a chlorhexidine-based solution prior to injections.

Precise-Sculpt technique

Fully evaluate the patient's face noting the shape, topography, and areas of volume loss. Use the patient's anatomy as a guide; it is not necessary to get overly creative. Dividing the PLLA into separate syringes allows for proper product allocation. Each syringe will be injected into a particular anatomical area using a specific injection style. Unless otherwise specified, the needle is introduced at a 30- to 40-degree angle to the skin. Once in the subcutis the needle angle is reduced to about 10 degrees and advanced. Always pull back on the plunger prior to injecting. If a flash of blood is obtained, withdraw the syringe completely, change needles, and reinsert. Most injections are done in the periosteal plane or deep subcutaneous fat and in a retrograde fashion. Avoid injecting into superficial fat and muscle. All injections should be done slowly. Massage firmly during and immediately after the procedure ([Fig. 59-1](#)).

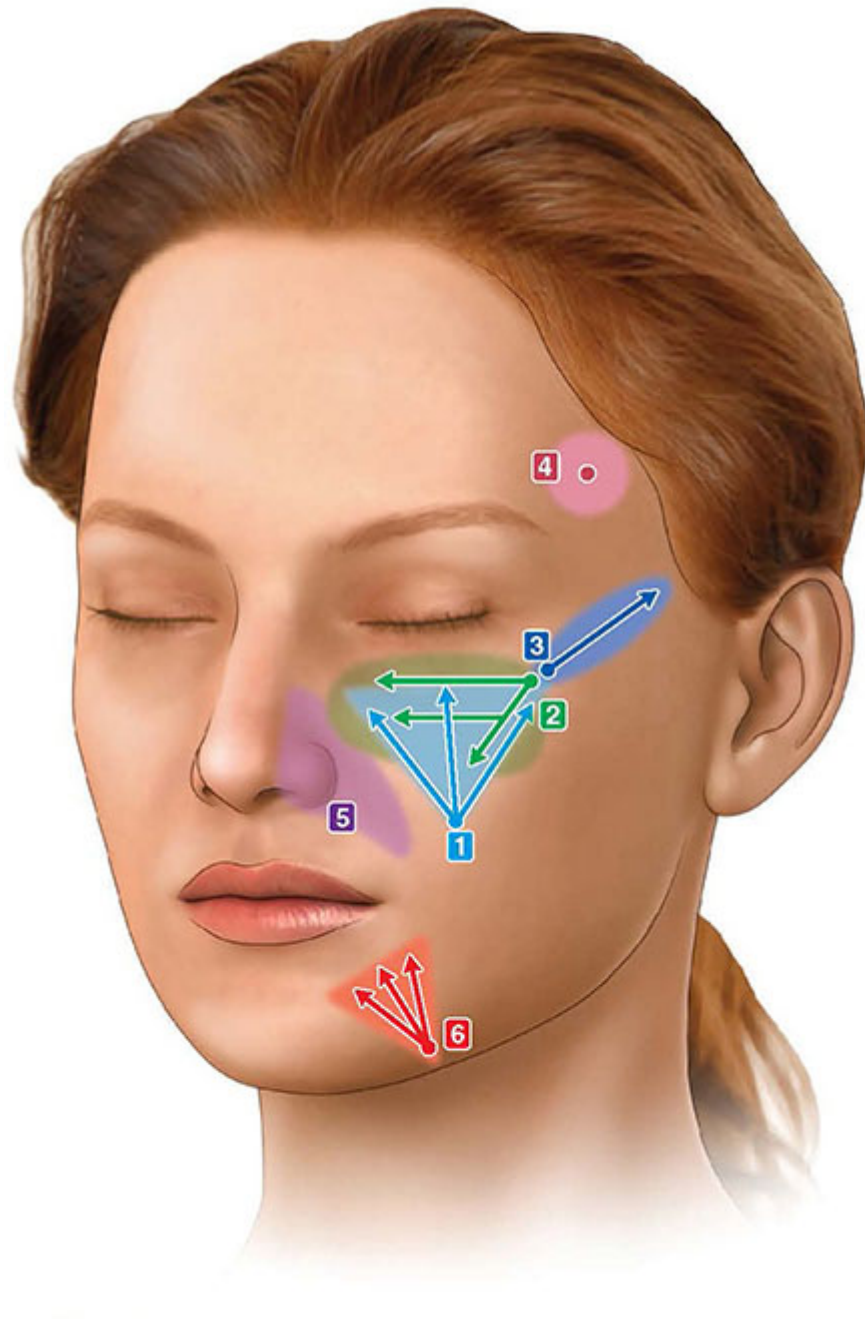


Figure 59-1. The Precise-Sculpt technique relies on a series of injections to accomplish facial augmentation. Numbers in this figure correspond to the syringe number; a total of 6 syringes are used, with a 7th dilute syringe reserved for touch-ups as needed.

Syringe #1—Retrograde fanning

The anteromedial cheek is pinched and lifted up with the injector's nondominant hand. The needle is introduced approximately 2 cm inferior to

the zygoma with the tip of the needle directed toward the medial canthus. Advance the needle to the periosteal plane. Care should be taken to avoid getting too close to the infraorbital foramen. Pull back on the plunger prior to injecting to confirm the needle is not in a vessel. Slowly inject approximately 0.2 to 0.3 mL in a retrograde fashion. Partially withdraw the needle, redirect 15 to 20 degrees laterally, and repeat the process. A total of 3 linear retrograde injections are performed with the last injection angled toward the lateral canthus.

Syringe #2—Retrograde parallel/cross-hatch

The needle is introduced over the zygoma lateral and inferior to the lateral canthus with the tip directed medially. Again, avoid placing the tip of the needle near the infraorbital foramen. Pull back on the plunger prior to injecting to confirm the needle is not in a vessel. Slowly inject approximately 0.2 to 0.3 mL periosteally along the anteromedial cheek in a retrograde fashion. Partially withdraw the needle, redirect inferior and parallel to the first injection, and repeat the process, injecting in a retrograde fashion. Partially withdraw the needle, redirect approximately 45 degrees inferiorly, and inject the remaining 0.1 to 0.2 mL. These injections should cross-hatch with those of syringe #1.

Syringe #3—Lateral zygoma

The needle is introduced at the apex of the cheek and directed laterally. The apex can be found at the intersection of Hinderer's lines. In a female, the first of Hinderer's lines is drawn from the lateral canthus to the oral commissure and the second from the tragus to the alar lobule ([Fig. 59-2](#)). In a male, the first line is a vertical line drawn directly down from the lateral iris and the second from the tragus to the alar lobule (this corresponds to the apex in a male cheek being inferomedial to a female's). The needle is inserted at a 30- to 45-degree angle directed laterally. Once in the subcutis the needle angle is reduced to 5 to 10 degrees. Pull back on the plunger prior to injecting to confirm the needle is not in a vessel. Slowly inject in an anterograde fashion approximately 0.2 to 0.3 mL periosteally along the zygoma while holding the needle stationary. The product can be appreciated tracking along the zygoma toward the hairline. If the product begins to migrate superiorly or inferiorly, stop injecting and withdraw the needle completely. Move laterally along the

zygoma, reintroduce the needle, and repeat the process. The goal is to follow the zygoma to the hairline.

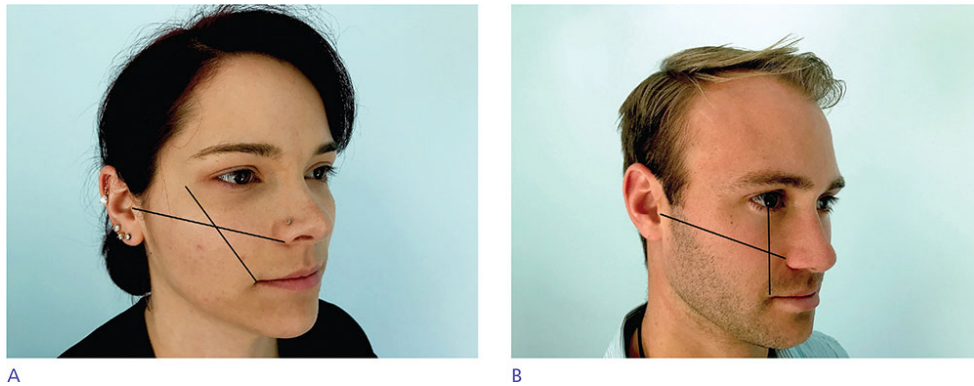


Figure 59-2. Using Hinderer's lines to determine the point of maximal zygomatic projection. In a female (A), the first of Hinderer's lines is drawn from the lateral canthus to the oral commissure and the second from the tragus to the alar lobule. In a male (B), the first line is a vertical line drawn directly down from the lateral iris to the lateral oral commissure, and the second from the tragus to the alar lobule. This corresponds to the apex of a male cheek being inferomedial to a female's.

Syringe #4—Temporal fossa

Instruct the patient to open their mouth wide, relaxing the temporalis muscle. The needle is introduced perpendicular to the skin over the temporal fossa using caution to avoid any visible vessels. Advance the needle to the temporal periosteum. Pull back on the plunger prior to injecting to confirm the needle is not in a vessel. Slowly inject a periosteal bolus. The entire syringe may be used if clinically necessary. Massage with deep pressure after completing.

Syringe #5—Nasolabial fold and maxilla and/or custom

The needle is introduced to the skin of the cheek just medial to the midpoint of the nasolabial fold with the tip of the needle directed toward the alar groove. Pull back on the plunger prior to injecting to confirm the needle is not in a vessel. Slowly inject approximately 0.2 to 0.3 mL in a retrograde fashion parallel to the nasolabial fold. Partially withdraw the needle and redirect toward the nasal septum and repeat the process while injecting on the maxillary periosteum. Completely withdraw the needle. Reintroduce the needle just medial to the inferior pole of the nasolabial fold and repeat the process while injecting in a retrograde fashion parallel to the nasolabial fold. Of note, this syringe is often utilized in another area that may need more

volumization as determined by the injector, making syringe #5 the “custom” syringe.

Syringe #6—Mandible

Just medial to the prejowl sulcus, the mentalis muscle and soft tissue are pinched and lifted up with the injector’s nondominant hand. The needle is introduced to the skin anterior and parallel to the mental tubercle with the needle directed superiorly. Advance the needle and pull back on the plunger prior to injecting to confirm the needle is not in a vessel. Slowly inject approximately 0.2 to 0.3 mL in a retrograde fashion. Partially withdraw the needle, redirect 15 to 20 degrees laterally, and repeat the process. A total of 3 linear retrograde injections are performed with the last injection angled toward the oral commissure.

Syringe #7—Dilute “bonus” syringe

It is not necessary to use syringe #7. It may be used for subtle corrections specific to the individual patient or to supplement a previously injected area. Avoid overcorrecting treatment areas (Figs. 59-3 to 59-8).



Figure 59-3. The patient received Radiesse (+) for contouring (2 syringes) for the midface and 2 syringes for the lower face. She also received 1 syringe of Juvederm Ultra XC to provide support to the

mouth and lips. (A) Before and (B) after.



Figure 59-4. The patient received 2 vials of Sculptra using the Precise-Sculpt technique. Sculptra for this technique is suprapariosteal with a 6-cc dilution. (A) Before and (B) 8 weeks post procedure.



Figure 59-5. The patient received Voluma on the midface, Botox 20 units to the masseter muscles, Juvederm Ultra XC on the bridge of the nose, and Radiesse (+) on the chin. (A) Before and (B) after.



Figure 59-6. The patient received one session of Sculptra (2 vials) diluted with 6-cc suprapariosteal. (A) Before and (B) 8 weeks post procedure.



Figure 59-7. The patient was treated with Radiesse (+) on the midface, jawline, chin, and temples. (A) Before and (B) after.



Figure 59-8. The patient was treated with Radiesse (+) on the midface and temples, and a small amount of Juvederm Ultra on the lips. (A) Before and (B) after.

Postoperative care

Instruct the patient to massage at home using the “rule of 5’s” (5 minutes, 5 times per day for 5 days). Schedule a follow-up appointment in 8 to 12 weeks. Depending on the degree of volume loss a second and even third treatment may be necessary for optimal results. Treatments should be scheduled 8 to 12 weeks apart. Results can be maintained with a yearly “touch-up” using the same technique with only 1 vial instead of 2, using half the volume per injection as listed above.

JOWL CORRECTION

Correction of mild to moderate jowl formation can be accomplished with the following steps. Identify and outline the jowl, which typically resembles a “U” shape. Mark the recommended insertion points at both the pre-jowl sulcus and the mandibular angle. The pre-jowl sulcus is found anterior to the “U”-shaped deformity or by extending a vertical line down from the outer alar rim. The boney architecture is recreated using 0.1- to 0.2-mL suprapariosteal boluses of product. In addition, a retrograde linear threading technique at the dermal–hypodermal junction with the use of a blunt-tip cannula will further contour the jawline.

The last step addresses the posterior cheek vector in patients with more severe jowl formation. An insertion point is created just inferior to the zygoma directed toward the “U”-shaped deformity (jowl). Use of a blunt-tip

cannula is recommended in this location. The injection is performed using a retrograde fanning technique. When performed properly this technique will further enhance the jawline and lift the lower face.

Technique Pearls

Prior to initiating any aesthetic treatment, an individualized assessment of each patient is required. While there is an important artistic component to analyzing each face, there are important quantifiable factors as well. Beauty, traditionally considered subjective, has more recently been found to consist of many objective markers that transcend racial and ethnic backgrounds. Symmetry, youthfulness, facial averageness, sexual dimorphism, and certain proportions are such contributors.⁶³ The aesthetically ideal face often follows the framework of *phi*, known as the Golden Ratio of 1:1.618. This ratio is consistently reproduced throughout the universe, nature, and the human body and its contributions to facial beauty are well documented. In a female patient with an eyebrow length of 1.618 for example, the most aesthetically appealing position for the peak of the brow is at 1. For a face with a nose width of 1 measured at the alae, the width of the mouth is ideally 1.618. An upper lip height of 1 is best balanced with a lower lip height of 1.618.

Following *phi* is not an absolute rule, however. In many cases, deviations are natural. No two patients present with identical needs and racial differences must be considered. While beautiful people of all races share many characteristics, it is important to preserve distinct ethnic variations. For instance, Hispanics and African Americans often have upper and lower lip ratios closer to 1:1, deviating from the Caucasian standard of 1:1.618. In the interest of maintaining facial averageness in these groups, this difference is important to optimize results and patient satisfaction when injecting lip fillers.

Midface Rejuvenation

An effective starting point for rejuvenating or aesthetically enhancing the face with fillers, regardless of race or sex, is to focus on the zygomatic bone. Some studies suggest a larger bizygomatic width to facial height ratio, measured from the upper lip to upper eyelid or brow, is associated with attractiveness.⁶⁴ As aging progresses, bony resorption and deflation of deep fat pads lead to a flatter, more sunken midface and reduced bizygomatic width. To correct this deficiency, fillers placed supraperiosteally along the zygoma as well as in the deep medial fat pads are helpful. As noted previously, Asians and African Americans tend to present with higher bizygomatic widths but aesthetic enhancement to this area is still beneficial as long as the injector is careful not to overly exaggerate the area.⁶⁵ Injecting the apex of the zygoma—the point of maximal anterolateral projection—is particularly beneficial in lifting the face. Adding volume at this position can produce more light reflectance and create the illusion of added lift and volume.

Use of Hinderer's Lines

To identify the zygomatic apex, map out Hinderer's lines. These are two lines described by Hinderer, a pioneer in malar augmentation. The point of intersection of these two lines reliably identifies the apex.

The position of a male and female apex varies slightly (Fig. 59-2). To identify the position in a female patient, first draw a line connecting the midtragus to the ipsilateral nasal ala. The second line is drawn from the lateral orbital rim to the ipsilateral oral commissure. The intersection of these two lines is the apex. In male patients, the first line is drawn from the midtragus to the nasal ala but the second line is drawn from the lateral iris to the oral commissure. Note that in female patients, the apex is located in a slightly superior and lateral position when compared to males. Over time, the apex will become readily apparent in the initial facial analysis and Hinderer's lines will be referred to less frequently.

When treating female patients, place filler along the superior aspect of the zygoma. Females tend to have more superficial adiposity in the anteromedial cheeks that shrinks over time, so adding product to this region is beneficial and helps attain the desirable ogee curve of the midface. To avoid feminizing male patients, injections should be placed slightly inferior to the superior border of the zygoma. In addition, as

males tend to have a flatter anterior cheek region, it is important to avoid overfilling this area. Pursuing an ogee curve on the midface of a male patient is not recommended.

To maximize results in the midface, the product should be placed supraperiosteally rather than in the deep dermis or subcutaneous tissue. This allows for more of a lift while using less product. Injecting small aliquots of 0.05 to 0.2 mL is preferred. Aliquots larger than 0.2 mL can often lead to unusual appearing lumps or bumps of which patients later complain.

African-American Patients

As African-American skin has more melanin throughout the epidermis, postinflammatory hyperpigmentation following procedures is a risk that must be considered. While hyperpigmentation following injections is rare, it can present a challenge if it occurs. Treatment of any laser- or injection-induced pigment can be alleviated with combined use of hydroquinone cream and multiple sessions of low-fluence fractional nonablative laser (i.e., long-pulsed Nd:YAG). The use of smaller gauge needles and avoidance of a serial puncture technique, whenever possible, is encouraged to further mitigate this potential risk.

Regarding lasers, one should be especially wary of treating light skinned African-American patients. Though their Fitzpatrick score may be lower than average for their ethnicity, the larger melanosome size and distribution present in the epidermis are more consistent with darker-skin types. Using a reduced fluence and appropriate pulse duration is recommended. This is true for other patients with lighter skin than average for their ethnicity.

Asian Patients

A recent cosmetic trend in Asian patients is contouring of the lower face with neurotoxin. Asian female patients tend to have wider lower faces with a widened mandibular arch and hypertrophic masseter muscles. To achieve more aesthetically balanced ratios, reducing the prominence of the masseters is desirable. In treating this area, care must be taken to avoid placing any neurotoxin anterior to the anterior border of the masseter muscle to avoid affecting muscles involved with smiling. For

this reason, it is encouraged to draw a line at the anterior portion of the muscle while the patient is biting down to ensure injections are placed posterior to this border.

Male Patients

Male anatomy varies substantially from female patients. As mentioned, males tend to have a flatter midface and anterior cheek region. Eyebrows tend to be flatter and lower lying, while the jaw and chin are usually wider. In general, the male face is more angular, differentiating it from the soft, curved, and round features of a typical female face. Male faces are also larger on average and require more filler and neurotoxin to achieve optimal outcomes. Though males tend not to seek augmentation or revolumization of the lip region, when they do, it is recommended to use less volume and to avoid injecting the vermilion border to avoid any obvious signs of treatment.

Pitfalls

Understanding facial anatomy is key to minimizing adverse reactions in all patients. Of course, every face varies from textbook anatomical drawings so other steps must be taken to reduce the incidence of bad outcomes. Prior to injection of any filler, pulling back on the syringe's plunger should always be done to ensure the needle is not placed intravascularly, though recent research has suggested that the lack of a blood flash does not guarantee that the needle is not intravascular. When using calcium hydroxyapatite, consider transferring the product to a 1-cc syringe which allows for easier aspiration. Utilizing a retrograde injection technique when possible and avoiding large boluses are also helpful. Recently, handheld vein finders have become available and may be helpful in lessening the risk of intravascular injection while decreasing ecchymosis.

In addition to taking the above measures, being able to recognize an intravascular injection promptly is critical. One of the worst pitfalls in aesthetic medicine is mistaking impending necrosis from intravascular injection for a common bruise and subsequently having the patient ice the area, further compromising blood flow. The first indication of intravascular injection is immediate blanching of tissue. Pain can be a

symptom as well but not all patients experience this, as many products are mixed with anesthetic. Several hours after injection, a purple–maroon reticulated patch usually appears in a distribution consistent with the course of the injected vessel. Pustule formation followed by further darkening of tissue suggests impending necrosis. Since the pustules can appear grouped and in a dermatomal pattern, an unsuspecting provider may misdiagnose this as varicella zoster infection. It is important to avoid this pitfall. Key steps to take immediately upon suspicion of intravascular injection or vascular occlusion include injecting the affected area with hyaluronidase (150 units or more), applying nitric oxide ointment, frequent use of warm compresses, vigorous massage, and taking aspirin daily.

Poly-L-Lactic Acid

PLLA is suitable for most patients older than 50 years. The product provides excellent versatility for panfacial revolumization. Injecting deep along the periosteum can help preserve the architecture and support of facial bones, acting almost as an injectable craniofacial implant.³⁴ Soft-tissue volume loss is also successfully addressed through neocollagenesis initiated by the product. To optimize results in a shorter period of time with fewer sessions, a 6-mL dilution of PLLA is recommended for suprapariosteal injections and a 9-mL dilution for soft-tissue placement. Reconstituting the product 72 hours prior to injection allows the PLLA particles to become fully hydrated and less prone to inducing nodule formation. Screening PLLA candidates for a history of keloids, sarcoidosis, or connective tissue disease is also recommended as these are contraindications.

MALE PATIENTS

Male facial anatomy and beauty vary considerably from that of females. While symmetry, averageness, and ratios approaching *phi* are important aspects to both male and female attractiveness, there are several sexually dimorphic features that greatly factor into the aesthetic ideal in males. Increased testosterone levels promote a squarer jaw, more prominent chin,

and fuller, lower-lying eyebrows. The anterior cheek region is flatter with less subcutaneous fat while the apex of the zygoma is slightly inferior and more medial compared to a female. An attractive male face is generally seen as more angular in shape when contrasted with the curved, soft, and rounded features of a female face. The goal in male patients is to create midface elevation with cheekbone enhancement.

A high G-prime volumizing filler such as calcium hydroxyapatite is an excellent choice to rejuvenate and aesthetically enhance a male face. The product's stiffness allows for sharper contours more suited for male patients. The authors utilize the *HD Sculpt* technique (as described below) for midface rejuvenation with reliable results. In addition to improving the midface, the achieved lift can also improve the appearance of mild to moderate jowls. Correction of jowl formation is described in a later section.

The first step of the *HD Sculpt* technique is to identify and mark the apex of the cheek. If not easily identified the apex can be found using Hinderer's lines. The first line extends from the lateral canthus to the oral commissure while the second extends from the midtragus to the nasal ala. Using a 27-gauge 1 ½-in needle, the syringe is introduced into the skin at a 30-degree angle along the lateral zygoma pointing toward the apex. Once in the supraperiosteal plane, the angle is decreased to 10 degrees and the syringe is kept parallel to the zygoma. The tip of the needle should approach the apex and arrives approximately 1 to 2 mm lateral to the apex. Injections are performed in a linear retrograde fashion moving laterally along the zygoma until reaching the hairline. A total of ~0.5 mL of product is used for this technique. This will naturally accentuate and define the patient's cheek while using the zygoma as a platform to directly lift the midface.

Next, the needle is inserted perpendicularly to the skin and a ~0.2-mL bolus of product is placed supraperiosteally at the apex. Continue injecting additional boluses of ~0.05 mL, moving laterally along the zygoma until desired definition and lift are achieved. Keep in mind the zygoma thins laterally so smaller boluses are needed.

POLY-L-LACTIC ACID

PLLA is a biosynthetic material that has been used safely for decades in the form of absorbable sutures, surgical plates in guided bone regeneration, and

as a drug delivery system. In its current form, PLLA has been on the market for over 15 years and has demonstrated safety and efficacy for the correction of nasolabial folds as well as other facial wrinkles and deficits with results that last up to 25 months.⁵⁷ It has also proven effective for restoring facial fat loss due to HIV-associated lipoatrophy.^{58,59} PLLA addresses multiple aspects of the aging process including restoring volumetric deficiencies and lifting descending soft tissues. The long-term effects are achieved by the stimulation of type-I collagen production.⁶⁰ Results are gradually attained as collagen generates and expands the dermis and underlying soft tissues. Secondary collagen stimulation from the mechanical stretching of fibroblasts also plays a role in the final result. Initial studies found a threefold increase in dermal thickness with sustained results at 2-year follow-up.⁵⁸ The clinical results of other soft-tissue fillers are more transient and can often require a large amount of product. Permanent implants can remain indefinitely but cannot accommodate continued age-related changes in appearance. Surgical facelifts and noninvasive skin tightening can improve the appearance of loose skin, but without volume the face still lacks youthful proportions.

Histologically, the PLLA microspheres elicit a subclinical inflammatory and fibrous tissue response. The microspheres are phagocytized and micronodules consisting of multinucleated giant cells are formed.⁶¹ In one study supporting the biocompatibility of PLLA, no residual polymer or remnant cicatricial fibrosis could be detected histologically at 9 months post injection.⁶²

Though not unique to PLLA, formation of delayed-onset papules, nodules, or granulomatous reactions are important adverse events that should be considered. In a phase 3 extension study, these complications occurred in 17.8% of treated compared to 12.8% of control sites, and appeared months later, often persisting for more than a year. Though the reconstitution and injection techniques described above may help mitigate some of these risks, this has not been rigorously studied.

CONCLUSIONS

As the popularity of fillers has increased dramatically over the past several years, appreciating the subtle differences in aesthetics between different

sexes and racial backgrounds is of critical importance to the dermatologic surgeon in order to be able to effectively and prudently treat a diverse patient population. Regardless of the particular products used, the principles of respecting the important yet subtle anatomical and aesthetic variations between sexes and races is a prerequisite to being able to effectively care for all patients in a responsible manner.

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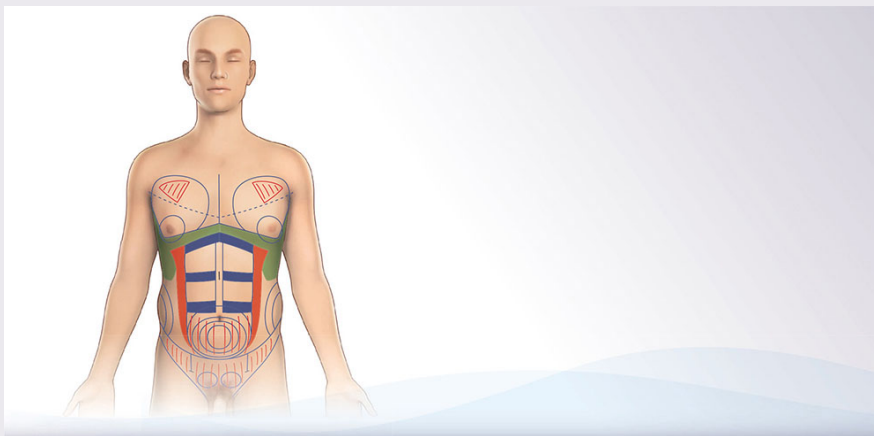
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CHAPTER 60 Liposuction

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SUMMARY

- The demand for a sculpted and defined body over one that is just flat has required surgeons to make advances in techniques and approaches to surgical body shaping that not only remove large volumes of fat in multiple locations at one time but also use this fat for muscular defining and body revolumization, while also addressing the desire for skin tightening and cellulite reduction.
- Patient expectations are significantly higher than in the past, as outstanding results are now expected in the consumer-driven, competitive aesthetic environment.

Beginner Pearls



- Combining traditional liposuction techniques with modern technologies such as VASER (vibration amplification of sound energy at resonance) ultrasound enables the surgeon to be a sculptor in which multiple steps are used to obtain a contoured and defined body that matches the underlying anatomical landmarks.
- Patients with significant loose or lax skin with or without stretch marks, higher BMI (>10 lb over expected weight), poorly defined or toned underlying musculature, and extreme cellulite are not ideal candidates for HDBC.

Expert Pearls



- To treat the superficial fat layer you must have (1) water-assisted (BodyJet) pressurized tumescence, (2) small (2–3 mm) rotary cannulas, and (3) VASER ultrasound multi-ringed probes.
- One component to the HDBC procedure is fat grafting to areas that require more muscular definition such as the male chest and shoulders or increased size and projection such as the female buttock and breast.

Don't Forget!



- Traditional power-assisted devices vibrate back-and-forth and extract fat by creating tunnels, increasing the ability to see irregularities and step-offs. Rotary power-assisted devices vibrate side-to-side in a rotational fashion physically shearing the tissue, allowing the surgeon to physically strip down on the thickness of the fat layer-by-layer without any tunnels.

Pitfalls and Cautions



- In the past, over-resection of the inner and outer thigh gave a smaller appearance, but also one that was flat and straight, more masculine, and ultimately unattractive.
- It is therefore common for an HDBC surgeon to add fat volume to the lateral buttock and thigh while removing fat of the upper buttock/lower back and inner thigh.

Patient Education Points



- Caucasian and Asian patients often desire a less-defined and curvy thigh, and want it to be as “stick thin” as possible, with a much less laterally projected buttock.
- In contrast, Latin/Hispanic and African-American patients desire much more prominent lateral thighs, larger buttocks, and very thin waists, often giving a less proportionate appearance.

CHAPTER 60 Liposuction

INTRODUCTION

The desire for improvement in body shape has increased dramatically in the past few years, mainly due to significant improvements in surgical techniques and reduced downtime as well as advances in nonsurgical approaches that not only reduce body fat but also tighten skin and improve cellulite. The demand for a “sculpted” and defined body over one that is just “flat” or “improved” has required surgeons to make advances in techniques and approaches to surgical body shaping that not only remove large volumes of fat in multiple locations at one time but also use this fat for muscular defining and body revolumization, while also addressing the desire for skin tightening and cellulite reduction.

Newer energy-based modalities such as vibration amplification of sound energy at resonance (VASER) ultrasound (as well as lasers/SmartLipo and radiofrequency/BodyTite treatments) allow surgeons to address not only the deep subcutaneous layers to remove bulk, but also work in the superficial layers for etching and muscular shaping, which has long been avoided due to increased complications and risk of irregularities. For a full body transformation, more aggressive high definition body contouring (HDBC) procedures can be combined with surgical implants and/or skin removal in a series of procedures to obtain a significant transformation. Postoperative care such as lymphatic massage and superficial radiofrequency (e.g., Venus Legacy and/or Exilis Ultra), vibration/shock therapies (e.g., Cellutone and/or Z Wave), and follow-up may be helpful to ensure long-term complications are minimal.

HISTORY

Over the past few decades, fat removal procedures have become increasingly popular, correlating with an increased desire for the perfectly smooth, contoured, lifted, and cellulite-free body. Increased social awareness of “healthy” and “organic” lifestyles and a renewed stress on health and beauty have popularized surgical and nonsurgical body contouring procedures. In 2017, liposuction was the second most common plastic surgical procedure performed, and nonsurgical fat reduction had developed a household name due to increased advertising to consumers.¹

A decade ago, liposuction was the only option for fat removal/reduction and the only option for any body contouring (e.g., shaping and tightening of the body) beyond having truly invasive skin removal surgery.^{2,3} Looking back, the results obtained with traditional surgical liposuction methods almost match that of our current nonsurgical options such as freezing of the fat (e.g., Coolsculpting) (Fig. 60-1A and B). At this moment, nonsurgical combination therapy (e.g., Coolsculpting) in combination with laser (e.g., SculpSure), radiofrequency (e.g., Vanquish, Venus Legacy, Thermage, and/or Exilis Ultra), ultrasound (e.g., Ultrashape), and/or vibration/shock therapy (e.g., Cellutone and/or Z Wave) can together nearly approximate the results of traditional liposuction (Fig. 60-2).

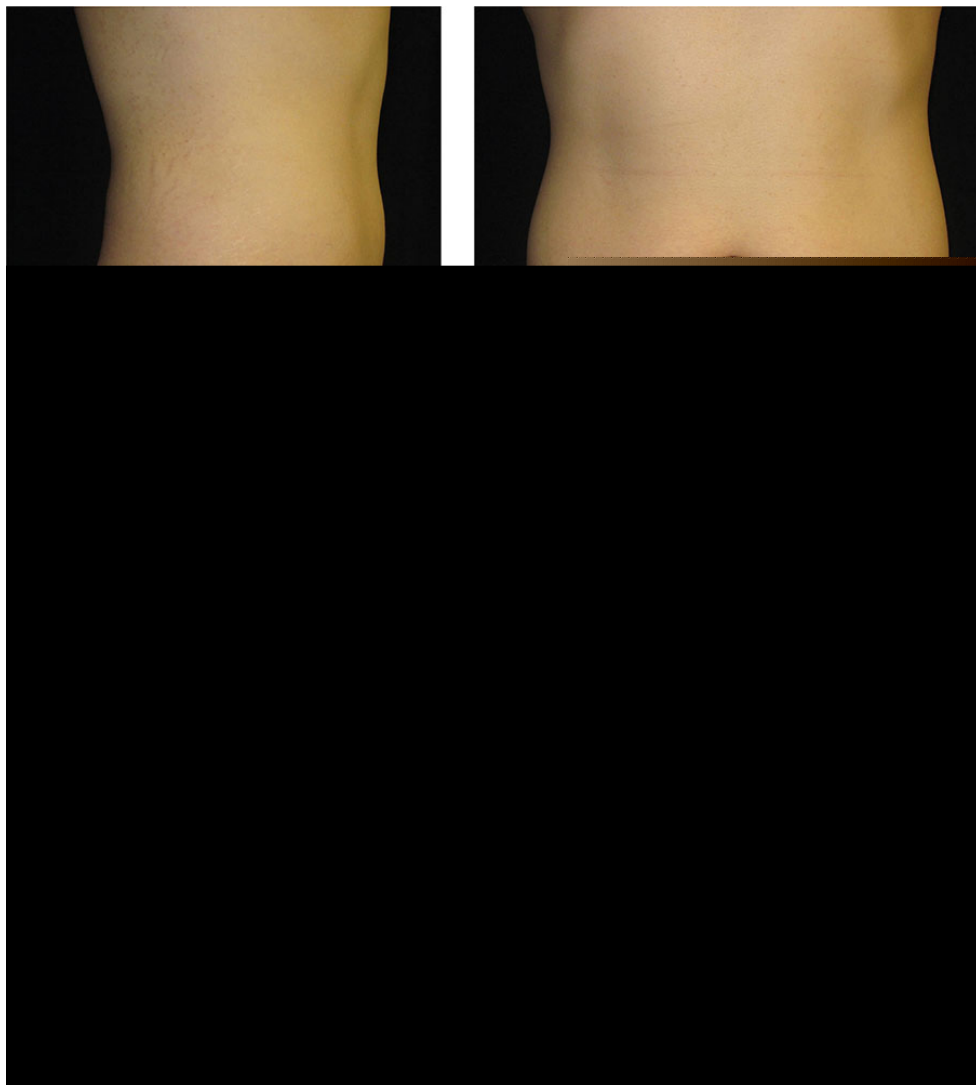


Figure 60-1. Traditional tumescent liposculpture (circa 2007). Standard approaches give some improvement in overall fat reduction and contouring, but results seen here are close to what can be obtained with nonsurgical body contouring methods. **A, B:** before; **C, D** after traditional liposuction.

several curves and chief lines that define it. The chief anterior line extends from the suprasternal notch along the midline of the linea alba to the umbilicus, while the chief posterior line is in the midline of the back between the erector spinae.¹⁰ Additionally, in those females that truly desire a more athletic look, lateral rectus definition, hip contouring (anterior superior iliac spine), and lower sacral dimples can be created or enhanced using superficial liposuction techniques. It is not common for females to have horizontal lines at tendinous insertions of the rectus abdominis (“six-pack”) as this is a more masculine feature and should be avoided unless the female is truly a candidate for this type of etching (Fig. 60-14A and B).

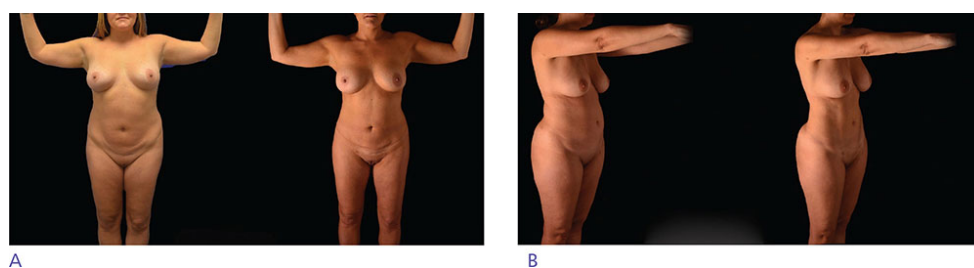


Figure 60-14. (A) Female high definition body contouring without tight skin. Same patient in different angles showing results before (left) and 3 months after (right) high definition body contouring of the circumferential torso, arms, and thighs, with fat grafting to the buttock. This patient is not a candidate to get a tight, contouring high definition outcome as she has moderate skin laxity without muscular definition. Nonetheless, you can see the significant bulk reduction in fat and skin tightening and body shape achieved after a VASER sculpting procedure. (B) Female high definition body contouring with tight skin. Same patient in different angles showing results before (left) and 3 months after (right) high definition body contouring of the circumferential torso, arms, and thighs, with fat grafting to the buttock. This patient is a candidate for a high definition outcome as she has almost no skin laxity and adequate underlying muscular definition.

Excess fat of the thighs also needs to be addressed in females, and is a major problem area and an extreme area of disproportion for most women. In the past, over-resection of the inner and outer thigh gave a smaller appearance, but also one that was flat and straight, more masculine, and ultimately unattractive. This area needs to be treated in a 360-degree fashion, keeping lateral curves and some thickness to the anterior and inner thighs so that a proportionate leg shape is maintained. The breast, buttocks, and lateral thighs are frequent areas requiring enhancement or contouring with fat transfer in order to create a smooth transition between the hip and leg. It is common for an HDBC surgeon to add fat volume to the lateral buttock and thigh while removing fat of the upper buttock/lower back and inner thigh.

This technique gives the buttock a more round appearance and further enhances the “S-curve” that is created when sculpting of the abdominals, flanks/sides, and lower back is performed (e.g., improving the hip-to-waist ratio). Even without any leg contouring, the buttock and hips will look more shapely by fat reduction and skin tightening of the lower back and flanks/sides. Additionally, fat removal is more common in places like the calves and ankles in females, but is an uncommon area of expertise for most surgeons.

Early treatment of the neck with sculpting along the jawline/lower face from both a midline (submental) and lateral position (preauricular) will tighten and contour this area and be preventative to early neck aging/sagging. Cellulite can be treated with combination approaches such as motorized subcision (e.g., Cellfina), fat transfer, and/or internal radiofrequency (e.g., ThermiRF) during the surgical procedure, and maintained with external heating devices (e.g., Exilis, Venus Legacy, Ultherapy) and injectable collagen stimulation with poly-L-lactic acid (e.g., Sculptra).

Ethnic, geographic, and cultural variation in shape in female buttocks

It is important to recognize differences between cultures and ethnicities when performing an HDBC procedure. Caucasian and Asian patients often desire a less-defined and curvy thigh, and want it to be as “stick thin” as possible, with a much less laterally projected buttock. In contrast, Latin/Hispanic and African-American patients desire much more prominent lateral thighs, larger buttocks, and very thin waists, often giving a less proportionate appearance.

MALE PHYSIQUE

In contrast to a smooth, soft, and curved female body, a male body is more rectangular/square, tight, and defined. In almost all cultures, a V-shaped male body (more broad and wide upper body as compared to lower abdominals) with defined muscles and minimal fat is desired and found to be uniformly attractive. The male body is defined by the muscles’ shape, which gives it more of an edged/ridged and formed appearance. The HDBC procedure is successful upon complete fat removal in the deep adipose layer

(“debulking”) followed by very meticulous removal in the superficial layers over the tendinous insertions of the muscles beneath (Fig. 60-15).



Figure 60-15. Athletic male high definition body contouring with tight skin. Men with an athletic body shape and muscular definition before () high definition procedure get contouring results quickly ( were seen at 3 months) with permanent long-term etching of the musculature.

Decreasing fat in an even linear fashion is extremely important so that retraction of the skin is symmetric over the underlying muscle and displays a true etched appearance. Inexperienced surgeons are often nervous to fully reduce this layer and end up only partially doing so, leaving an irregular appearance and one that shows an initial improved appearance but is not maintained long term. For a permanent body change with defined lines, fascial adhesions must be created by aggressive superficial fat removal. The best aesthetic outcome is with a complete understanding of anatomy so that the surgical markings of the fat layers, underlying musculature, and adhesion zones (proposed defined lines) are defined and addressed through the surgery.

Abdominal etching includes aggressive removal of the deep fat layers of the torso, superficial etching of the linea alba (the vertical crease above the umbilicus), the linea semilunaris (the lateral or outside edge of the rectus muscle), the horizontal lines across the tendinous insertions of the rectus abdominis muscle (for the “six-pack”), and hip sculpting (anterior superior iliac spine). Slight irregularities need to be integrated in a defined pattern to ensure a natural look of the abdomen after the etching. It is imperative not to

forget liposuction of the mons pubis. The neck/face can also be addressed similarly to a female as preventative treatment.

Chest and chest wall, upper back, sacral, and arm/shoulder areas need to be addressed with any larger fat removal and reshaping to complete the body transformation. Most surgeons will forgo these areas due to the increased surgical and recovery times as well as inexperience in creating definition of these areas.

In men, it is helpful to create a more athletic shape by using harvested fat for muscular definition of the chest and shoulders (to give a more broad upper body appearance and lift the chest), buttock shaping, and calf contouring.¹¹ Fat may be harvested with water and ultrasound-assisted technologies into a filtration system (Puregraft) that removes debris such as oil, connective tissue, and blood to obtain the most pure fat for harvesting. PRP is added to the fat in a 2–4:1 ratio to possibly help survivability and longevity.

Finally, the male breast glands should be removed if they are evident after lipocontouring of the breast and fat injection into the muscle.

Poor planning and anatomical consideration in a prior male abdomen HDBC surgery

To create an abdominal six-pack or “V-taper” in a younger male desiring a more contoured abdomen, it is essential to identify all the tendinous insertions of the rectus muscles and aggressively define these areas while leaving a small amount of fat over the muscle bellies themselves (Figs. 60-16 and 60-17). Improper placement of presurgical markings can lead to an incomplete abdominal six-pack shape, and uneven resection of the superficial adipose layer can lead to fibrotic bands in the wrong location causing superficial irregularities often seen best during flexion/extension (Fig. 60-18A and B).

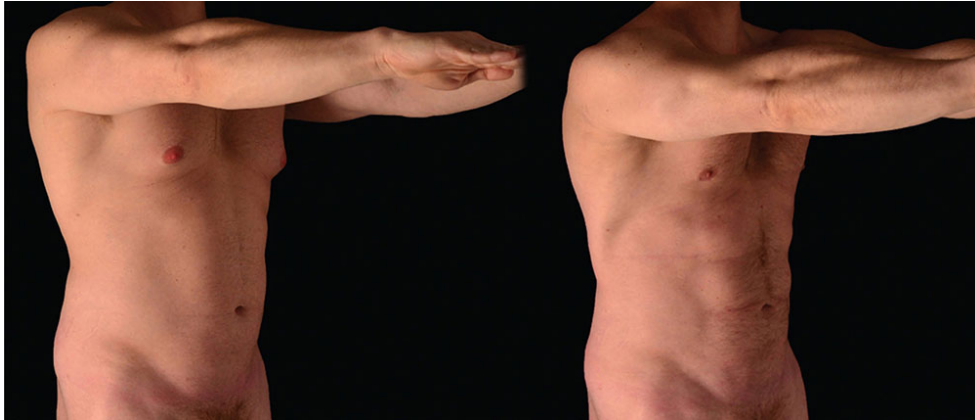


Figure 60-16. Men with a slightly higher baseline body fat percentage also benefit significantly from etching and high definition body contouring.



Figure 60-17. Athletic male six-pack and “V-taper.” Six months result showing high definition athletic shape of the abdominal musculature with tapering at the lower abdominals and hips. Proper placement

of markings over anatomical landmarks with both deep suction and superficial etching gave an optimal outcome.

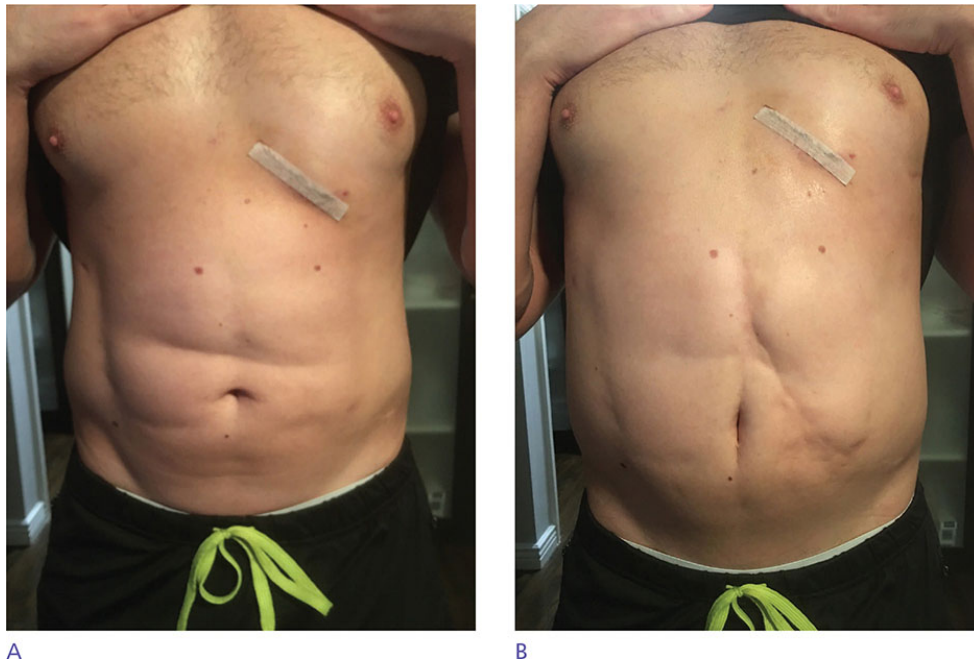


Figure 60-18. (A and B) Athletic male six-pack with poor outcome. Six months result showing abdominal musculature without proper etched lines and fibrosis and asymmetry worse with extension. This outcome was due to inappropriate liposuction of the superficial fat and poor removal of the deep layers without contouring. This is an example of a poor cosmetic outcome from another cosmetic surgeon that will require revision surgery to repair.

Planning and anatomical considerations in a male chest revision surgery

The male chest requires four steps to obtain the best contouring: (1) VASER ultrasound, (2) Rotary power-assisted liposculpting, (3) Fat injections with PRP to the chest musculature, (4) male breast gland removal (Fig. 60-19). In this instance a patient had a traditional approach of minimal hand aspiration liposuction to the chest with over-resection of the male breast glands leading to a “flat” appearance without contour. To repair this, HDBC of the chest and chest wall was performed in the superficial layer to define a new lower and lateral border of the chest. Fat was harvested and injected into the upper pole of the chest for lift and volumization as well as behind the nipple to give

projection. Additionally, fat was injected into the shoulders to give the upper body a more broad appearance.



Figure 60-19. Male chest high definition body contouring revision. Fat harvesting of the chest and shoulders with sculpting liposuction of the lower chest, chest wall, and shoulders to give improvement in upper body shape and muscular definition. (A) Pre-procedure. (B) Post-procedure.

SURGICAL APPROACH

Full body shaping requires significant downtime and surgical planning. If numerous areas of the body are to be reduced in size and contoured, for safety reasons the procedures need to be staged. In some instances, surgical cutting/skin removal and/or permanent implants are needed to for the best outcome, and recovery time is needed between procedures.

In both males and females, the procedures are staged to keep each procedure less than 5 L in fat removal. These procedures are generally performed under general anesthesia. Local tumescent approaches make it almost impossible to obtain an adequate amount of fat removed and body contours created without significant pain. Moreover, limitations in the amount of anesthetic require patients to undergo general anesthesia with a variation in the traditional tumescent fluid to limit toxicity (Table 60-1).¹²

Table 60-1. Tumescent Fluid for HDBC

1-L normal saline or lactated Ringers solution
10 cc of 2% (20 mg/mL) lidocaine hydrochloride ^a
2 ampules of 1:1,000 (1 mg/mL) epinephrine
1 cc (10 mg) of triamcinolone acetonide (Kenalog-10)
12.5 cc of 8.4% (1 mEq/mL) sodium bicarbonate

^aFor local tumescent cases that are not HDBC, dose increases to 50 cc per 1 L of fluid.

Typical staging of a female full body contouring procedure

Procedure 1: Calf/ankle and forearm

Procedure 2: Circumferential torso, upper arm, buttock

Procedure 3: Circumferential thigh

In any of these procedures, neck and face liposuction, fat transfer, cellulite release (e.g., Cellfina), and/or skin tightening (e.g., ThermiRF) can be added. Implants and skin removal surgery are best performed during the last procedure if possible for the purposes of easier healing and simpler postoperative recovery. However, the procedures are tailored to the individual patient. Those with lipedema (larger amounts of disproportion) may require a fourth surgery that addresses sections of the buttock or thigh that could not be addressed in the previous procedures. In some patients, the full upper body (torso and arms), calves and full medial thighs, and knees can be addressed in one longer procedure without increased risk and fitting within the guidelines of acceptable safe amounts of fat removal in a single procedure if they are more athletic and require more contouring and shaping than large volume fat removal. Fat transfer is typical in the breast, buttock, and thighs to give a more “S-curve” and projected buttock and hip. A typical expectation for improvement on the breast is 0.5 to 1.5 cup size, but to maintain fat viability in this area a series of future fat injection touch-up procedures may be needed. Facial augmentation with any additional fat can give great improvement in facial contour as well as fine wrinkles of the neck and chest.¹³

In the male athletic patient, the majority of all the work desired can be performed in a single procedure. The length of the procedure is extended if the patient requires skin removal surgery/body lifting (e.g., abdominoplasty, nipple lift) (Fig. 60-20). If the patient is larger and has significant “debulking” fat removal that is necessary, this should be done in a process as shown above in the female, and 3 to 6 months should be waited until a high definition contouring procedure (etching, sculpting, fat transfer) is performed.

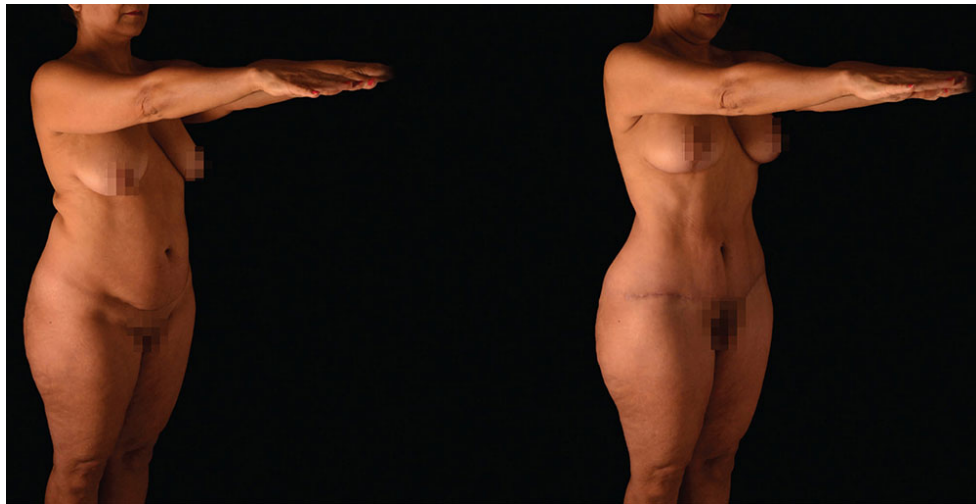


Figure 60-20. Female high definition body contouring with abdominoplasty and breast lift. Before (left) and 3 months after (right) high definition body transformation procedure. This patient had children and was left with loose skin of the abdomen and breast descent. A high definition body contouring liposculpting procedure of the circumferential torso, arms, and inner thighs was performed with fat grafting to the buttocks. Abdominoplasty was performed to tighten the lower abdominal skin in order for liposculpting to provide a more athletic contour. Breast lift was performed to improve the appearance and size of the breasts, completing the full body transformational procedure.

Typical staging of a male full body contouring procedure

Procedure 1: Circumferential torso, chest, and arms with male breast gland removal, fat transfer

Procedure 2: Circumferential thighs

The face and neck are often treated in the first procedure unless rhytidectomy is planned, in which case it would be performed in the second procedure along with the skin cutting procedure. If a significant amount of

skin removal is needed for full body lifting, the procedures are staged, but liposuction is performed at the same time immediately before the skin removal to “debulk” the area and then continued afterwards to contour and shape. Fat injections are completed at the end, and typical locations include the buttock, chest, shoulders, and calves. Chest, buttock, shoulder, or calf implants are placed concurrently with the liposuction procedure but staged so that healing times are appropriate. For example, a full male high definition procedure that wanted a six-pack with chest and buttock contouring but required implants for best improvement would have full upper body liposuction with fat harvesting and injection to the chest and buttocks and only the chest implant placed (Fig. 60-21). A healing time of 4 to 12 weeks would be allowed before addressing other implants such as the buttock to allow for easier postoperative recovery and less body stress.



Figure 60-21. Male high definition body contouring with abdominoplasty and nipple lift. Before (A) and 6 weeks after (B) a high definition body transformation procedure. This patient had significant weight loss with loose skin of the chest and stomach, but had underlying athletic muscular tone. A high definition body contouring liposculpting procedure of the circumferential torso, chest, and arms was performed with fat grafting to the chest, shoulders, and buttocks. Abdominoplasty and nipple lifting were performed in order to obtain tightened lower abdominals and give chest definition and shape. The patient is shown here immediately after full body radiofrequency (Venus Legacy) and vibration/shock (Cellutone) therapy and lymphatic massage, which are performed weekly for up to 3 months.

Postoperative after care and follow-up

For an HDBC procedure, follow-up care and postoperative healing are essential to prevent complications and to ensure permanent body shape changes (Table 60-2).^{14,15} High definition procedures are much more aggressive than traditional tumescent approaches due to the increased number of areas treated in a single procedure, a larger amount of total fat removal as compared to standard small volume cases, as well as the superficial nature of etching. This can lead to more significant dehydration requiring intravenous fluid replacement starting 12 to 24 hours after the procedure, the development of a postoperative anemia requiring hyperbaric oxygen therapy, a higher risk of infection due to the insertion of drainage tubes requiring antibiotics to cover both staph and strep species, an increased risk of seromas even with proper double compression and lymphatic massage, as well as the development of fibrotic banding that requires radiofrequency and/or ultrasound manipulation of tissue immediately after the procedure and long-term (3–6 months) fascial massage. It is essential that in the preoperative evaluation and consenting process there is complete discussion over the postprocedural healing process with an HDBC procedure as this is extremely different (much longer and more difficult) than a traditional liposuction procedure and requires a significant number of steps after the procedure itself to ensure proper healing and an ultimate outcome that is permanent.

Table 60-2. Complications After HDBC Procedures

Short-Term Expected	Short-Term Unexpected	Long-Term Unexpected
Pain	Seroma	Permanent indentations/asymmetry
Swelling	Hematoma	Worsening cellulite
Bruising	Infection	Fat necrosis
Bleeding	Allergic reaction (tape or compression)	Fat calcification
Numbness	Inflammatory reaction	Skin necrosis with scarring
	Contour irregularity/"fibrous bands"	Skin discoloration/"erythema ab-liposuction"
	Burns	
	Pulmonary/fat embolism	

Lymphatic massage

Stagnant lymphatic flow can cause increased swelling and chronic inflammation, as well as increased seromas and fibrotic tissue after

aggressive surgery. Therapy should be started no more than 24 hours post procedure to facilitate tissue healing and a more rapid recovery.

Hyperbaric oxygen

Hyperbaric oxygen therapy (HBO) allows a patient to breathe concentrated oxygen at pressures greater than normal atmospheric pressure, helping the concentrated blood cells to speed up the healing process. It has been documented that with surgical cutting procedures HBO can decrease the rate of complications such as seromas, hematomas, and scarring.^{16,17} Increasing the blood flow and oxygenation to tissue also helps to increase the functional mobility of the body, which in turn helps patients return to activities much more quickly after an extreme procedure. Daily treatments for 2 weeks are helpful for HDBC procedures, especially if implants are placed and/or skin removal surgery is performed.

Ultrasound and radiofrequency devices

Similarly to lymphatic massage, manipulation of tissue through mechanical stimulation as well as heat increases ability for the skin to heal properly as well as decrease swelling. In one study, PAL combined with external ultrasound with or without postoperative deep tissue massage/suction (endermologie) was seen to decrease the overall complication rate, contour irregularity, and skin necrosis. There were no statistical differences regarding other complications.¹⁸ Radiofrequency skin manipulation (Exilis Ultra or Venus Legacy) may be used starting no more than 7 days after the procedure and continuing twice weekly for 3 months after superficial and/or large volume HDBC liposuction procedures. External ultrasound can begin the day after the procedure in conjunction with lymphatic massage.

Surgical drainage tubes

Placements of surgical drains are necessary in procedures that have large volume reduction and aggressive superficial skin manipulation. In traditional practice, port sites are left open to drain, but they often close too soon (estimated 24–72 hours in most instances) after the procedure, leaving fluid to build up and increasing the rate of seroma, chronic inflammation, and hematoma. This is a reason why port closure with sutures is also not recommended unless fat grafting has been performed in the area. When superficial liposuction is performed, drainage can occur for weeks, and tube

placement ensures fluid movement out of the body during the initial 1 to 2 weeks, after which the tubes will be removed and sites sutured closed if needed (for cosmetic purposes). If progressive tension suturing is used for the abdominoplasty, drains may not be required when liposuction is concurrently performed.^{19–21}

CONCLUSIONS

HDBC is as much a science as it is an art. The demand for a more sculpted and defined body has required surgeons to make advances in techniques and approaches to surgical body shaping that not only remove large volumes of fat in multiple locations but also use this fat for muscular defining and body shaping. Newer energy-based modalities have allowed these surgeons to address not only the deep subcutaneous layers to remove bulk but also work in the superficial layers for etching and muscular shaping that have long been avoided. For a full body transformation, more aggressive HDBC procedures can be combined with surgical implants and/or skin removal in a series of procedures to obtain an ultimate transformation.

Postoperative care and follow-up are essential to ensure long-term complications are minimal. Future studies may assess the importance of noninvasive devices in the postoperative healing phase as well as how to further improve contour, cellulite, and skin tightening results in conjunction with HDBC surgical techniques.

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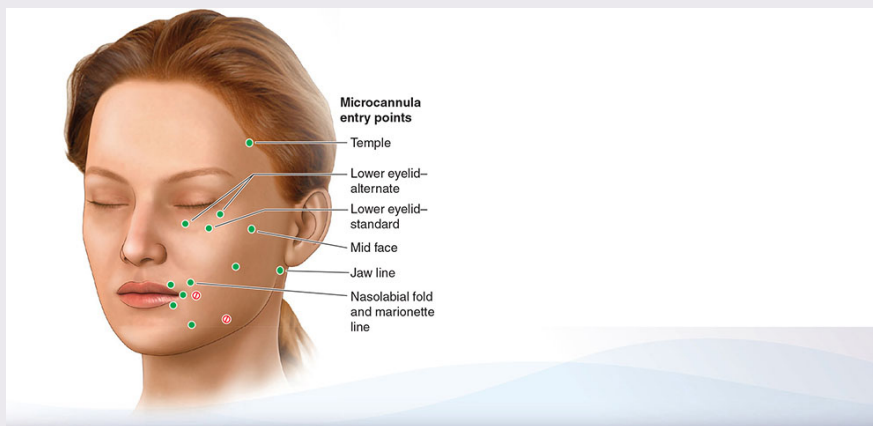
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CHAPTER 61 Fat Transfer

Marie DiLauro



SUMMARY

- Fat grafting is an involved, detailed procedure that requires planning, instruments, and expertise that may be gained by expert training and experience.
- Fat transfer can create an entirely new shape or replace volume that was lost.
- Choose donor sites ahead of time if possible, ideally body areas that show minimal change with weight loss.

Beginner Tips



- Avoid injecting fat into the forehead.
- Fresh fat is best. Avoid using refrigerated or frozen fat.
- Avoid using needles for fat injection.
- Inject only thin strands of fat at a time.

Expert Tips



- If the grafting cannula enters the oral cavity during injection, withdraw and do not use that cannula again to transfer fat.
- Avoid lumps in the face by injecting small volumes and molding the area after injection.
- Make significant overcorrections when placing fat in the body.
- Perform only slight overcorrections in the face, and watch for symmetry.

Don't Forget!



- Unlike facial fillers that can be purchased and are readily available to be injected, fat must be harvested from a separate donor site on the patient during a separate procedure.
- Some patients may find that filler injections are more convenient for them, and may not want the inconvenience of undergoing a small liposuction procedure prior to being injected.

Pitfalls and Cautions



- Be careful in the infraorbital area and do not overcorrect.
- Not only does fat have to be specially prepared, but it is not always smooth or easy to inject. Cannulas and syringes often become clogged, and fat transfer can be messy.

Patient Education Points



- Communication is critical, as patients must understand both the possibilities and the limitations of fat grafting.
- Most patients prefer some degree of overcorrection, as even in the best case scenario approximately 25% of grafted volume will be lost.
- Make sure you know exactly what shape the patient wants when they request buttocks augmentation.

Billing Pearls



- It may be cost-effective for patients to combine fat transfer with scheduled liposuction, as the added cost may be significantly less than performing the two procedures at different times.
- Patients may prefer to freeze excess fat for future transfer, as this may lead to significant cost savings and improved convenience; this must be weighed against a possible decline in fat quality after freezing and thawing.

CHAPTER 61 Fat Transfer

INTRODUCTION

Fat transfer, or the grafting of autologous fat from one area of the body to another, is a useful skill for any dermatologic surgeon who performs liposuction, body contouring or sculpting. Not only is fat transfer an effective method of providing a natural filler for facial aesthetics, but it can also be used for filling defects that occur during liposuction, correcting naturally occurring asymmetry and depressions, and remediating postsurgical depressions and scars.

For physicians performing facial rejuvenation, fat grafting is an important tool for correcting the facial hollowing and volume loss that occurs during the aging process. Unlike temporary fillers, transferred fat can create a youthful long-lasting natural shape and concomitantly contribute to facial rejuvenation through the action of stem cells present in the transferred fat.

HISTORY

Fat grafting was first described by Miller in 1926, though it was not commonly performed until liposuction became a popular procedure in the 1980s, when full face volume replacement with fat alone was attempted for the first time. This approach rivaled the appearance of a facelift, with lasting results. Since then, numerous methods and techniques for fat harvesting and injection have been developed and tested to determine the best way to achieve long-term adipocyte survival. Today multiple fat harvesting, separation, and transplanting techniques exist. These techniques continue to evolve in the quest to discover the best method to obtain, treat, and transfer

viable fat with predictable survival rates with permanent or long-term results.

CLINICAL INDICATIONS AND APPLICATIONS FOR FAT TRANSFER

Preoperative evaluation and planning

During the initial consultation, areas of cosmetic concern should be carefully delineated. The use of mirrors is very helpful, as is tactfully pointing out any observed preprocedure asymmetry to ensure that the patient has realistic perceptions and expectations. Digital photographs, including oblique views, can be helpful for pointing out positive features as well as potential targets for enhancement. Photographs from the patient at a younger age may be helpful as well, which can be used to analyze and discuss the changes that occur due to the aging process.

Patient selection

It is important that the patient understands the procedure, possible side effects, complications, and the recovery process. Not all the grafted fat survives, and additional fat grafting procedures may be needed to achieve the best results. In the face in particular, some fat loss will persist as part of the natural aging process, and subsequent facial fat enhancement may be needed.

Patients for facial fat grafting

Most patients who desire facial fat grafting have had prior treatments with fillers and neurotoxins. If a patient is filler naïve, it may be beneficial to treat the patient first with a biodegradable filler prior to performing facial fat grafting. In this way the patient will have the opportunity to understand the process and “try on” the new look.

The area that is to be grafted may also be treated with an appropriate dose of neurotoxin 2 to 3 weeks prior to the fat grafting procedure in order to obtain a smoother long-term result.

Standardized photographs

Standardized photographs of the patient's donor and recipient sites should ideally be performed prior to the procedure with frontal, lateral, oblique, and (if relevant) posterior views. It is also helpful to obtain photos with various facial expressions, and with the head tilted up and down.

Medical clearance and testing

Depending on the patient's medical history, preoperative medical clearance may be sought, though this is not an absolute requirement.

Donor site selection

When planning the transfer of a large amount of fat, the donor sites are usually the body areas that the patient has chosen for liposuction—typically the abdomen, hips, or thighs. To determine the best fat donor sites, the patient is asked what body areas remain relatively unaffected after a moderate weight loss of 10 to 20 lb. The fat in these resistant body areas may have lower metabolic activity and a higher antilipolytic activity than the fat in the patient's other body areas. Choosing these areas as donor sites may improve the longevity of the transferred fat should the patient lose weight in the future.

If a patient desires a large fat transfer procedure but does not have enough body fat available, they can be advised to return for a fat grafting procedure after a weight gain of 20 lb; in practice, this is a rare occurrence.

When planning a small fat transfer of less than 20 mL, any donor site that will not create an asymmetrical defect may be chosen. Common donor sites are the posterior hips, thighs, lower abdomen, or suprapubic area. If asymmetry is present in a body area, fat can be harvested from the larger side, or both sides can be harvested to avoid causing asymmetry.

Fat harvesting

The two common methods for fat harvesting are syringe liposuction or machine-assisted liposuction. Fat harvesting is performed under strict sterile conditions, and antibiotics may be administered starting the day prior to the

procedure, and can also be added to the harvested fat prior to performing the fat transfer procedure.

Donor site anesthesia

The same local tumescent solution used for liposuction can be used to anesthetize the donor site. One liter of modified Klein's tumescent solution consisting of 1 L of Ringer's lactate with 500-mg lidocaine, 1 cc of 1:1,000 epinephrine, and 12.5 cc of 8.4% sodium bicarbonate is prepared for infusion. When preparing the tumescent solution and nerve blocks, the lidocaine dosage is carefully calculated in the same manner as when performing liposuction procedures.

Instruments for fat grafting

Instruments include a fat harvesting cannula, fat grafting cannula, disposable cannula, 10- and 1-cc Luer lock syringes, and a syringe stand.

Patient preparation

Starting 2 weeks prior to the procedure, the patient is advised to abstain from all medications and supplements that may increase the risk of bruising or bleeding.

The day before fat grafting, the patient is advised to start cephalexin 500 mg twice daily, or ciprofloxacin 500 mg twice a day, and to continue for a total of 7 days.

Valacyclovir is prescribed starting 1 day before the procedure if facial fat grafting is to be performed.

Preoperative medication

The patient's weight, measurements, photographs, markings, and vital signs are taken prior to administering preoperative medication. For large fat transfer procedures, a mild sedative, such as diazepam 10 mg, is administered at least 30 minutes prior to the start of the procedure. If desired, an oral narcotic such as Lortab, which contains 10 mg of hydrocodone and

650 mg of acetaminophen, may also be administered. Prednisone 40 mg may also be administered orally if facial fat grafting is to be performed.

Patient marking of the body and face

Body areas for liposuction and fat transfer are marked with sterile surgical pens and permanent markers while the patient is standing in front of a mirror in the examination room. Areas of excess fat, depressions, the midline, and bony landmarks are carefully marked topographically with different colors, typically red for depressions, green or blue for excess fat, and black for bony landmarks. On the face, the areas for fat grafting, bony landmarks, location of the marginal mandibular nerve, and cannula entry sites are marked with the patient sitting upright in front of a mirror in the exam room. It is important that all detailed topographical markings are made prior to infusing any local anesthesia or tumescent solution, because the tumescence can obscure the soft tissue and bony landmarks of the face and body.

Patient preparation in the operating room

After the treatment areas are marked, the patient is brought to the operating room, prepped with chlorhexidine, and draped and positioned in a sterile fashion. An intravenous line may be inserted prior to the liposuction procedure. The patient may be connected to a cardiac monitor with continuous heart rate, blood pressures, EKG, and pulse oximetry throughout the fat harvesting and grafting procedure. If desired, an ultrasound system may be present in the operating room with a sterile sleeve attached to the transducer so that it can be utilized for ultrasonic guidance during the fat grafting procedure.

Before starting the fat grafting procedure, the recipient areas for fat grafting are re-prepped and new sterile drapes, gowns, and gloves are used.

Tumescent anesthesia by infusion pump

Tumescent infusion of the donor sites is performed with a blunt cannula in the same manner as when performing liposuction alone. After local anesthesia at the marked entry port is obtained, an incision is made with a 2.5- to 3.0-mm dermal punch or a #15 scalpel. Then a blunt 1.5-mm infiltration cannula is carefully inserted superficially parallel to the skin surface so that the outline of the cannula remains visible beneath the skin surface and the tip of the cannula can be felt and monitored by the opposite hand, the “smart hand,” at all times during the infusion. The infiltration cannula is used to slowly infuse

a small amount of tumescent solution into the superficial subcutaneous fat in the treatment area in a radial pattern, using an infusion pump. Infrasonic vibration handpieces may make the infusion phase more comfortable for the patient.

Tumescent anesthesia by syringe

For small donor sites, local tumescent anesthesia can be obtained manually via syringe. After a small bleb of local anesthesia is injected at the marked entry port, an incision is made with a 2.5-mm dermal punch or a #15 scalpel. A 22-gauge spinal needle or a 1.2-mm infiltrating cannula attached to a 10-cc syringe is carefully inserted superficially through the entry port, parallel to the skin surface. The area is then carefully infused beginning in the subdermal plane in a radial pattern, gradually extending into the deeper layers of the subcutaneous fat while remaining above the fascia, until the entire elliptical area of the donor site is tumesced.

Waiting period after tumescence

A 20-minute waiting period after the completion of tumescent infusion is recommended to permit vasoconstriction from the epinephrine to take effect.

During this waiting period, external ultrasound or vibratory massage can be performed on the donor sites prior to initiating liposuction to initiate a gentle fat emulsification.

Fat harvesting by machine liposuction

There are many options available for fat harvesting and fat extraction. Most methods are chosen based on improved fat survival and personal preference. Fat can be harvested by performing liposuction by hand with a syringe or by performing liposuction with a vacuum pump and an ultrasonic, infrasonic, or power-assisted device. Laser devices are not used for fat harvesting, as few viable fat cells are present in the aspirate after laser liposuction.

Many systems are used for machine harvesting, including the Power X rotational power-assisted device (Solta Medical); the ultrasonic Vaserlipo fat emulsion device (Solta Medical); and the infrasonic nutational Tickle Lipo fat emulsion device (Euromi). Liposuction for fat harvesting is typically performed in the same manner as liposuction for body contouring, with a few exceptions. A lower vacuum pressure is recommended for aspiration and

specialized harvesting cannula such as the Mendieta with the Power X and Rubelo or Viterbo on the Tickle Lipo are often utilized (Figs. 61-1 to 61-4).



Figure 61-1. A vacuum pump and the Power X rotational power-assisted device and the ultrasonic Vaser system can each be used alone or together to harvest fat for fat grafting.



Figure 61-2. The infrasonic nutational Tickle Lipo device by Euromi can be used to tumesce, emulsify, and harvest fat for grafting.



Figure 61-3. The infrasonic vibration of the Tickle Lipo nutational handpiece (Euromi) can increase patient comfort during infusion because of the gateway theory of nerve conduction of pain.



Figure 61-4. The Tickle Lipo nutational handpiece (Euromi) with aspiration cannula uses infrasonic energy to emulsify fat while aspirating fat, providing a more comfortable experience for the patient while producing a lipoaspirate that is rich in viable adipocytes.

Fat harvesting by syringe

When harvesting modest amounts of fat, manual syringe harvesting may be performed.

1. Connect a Coleman harvesting cannula to a 10-cc syringe.
2. Insert the cannula through the entry port into the middle depth of the excess subcutaneous tissue at the donor site.
3. After insertion, pull the barrel of the syringe back about 1 to 2 cc to maintain continuous suction while making several back and forth motions in a radial pattern at the donor site in order to harvest the fat.
4. When the syringe is full of fat aspirate, cap it, and place it vertically in the syringe stand.
5. Allow the syringes to stand for several minutes to allow gravity separation to take place.

Fat collection and separation

Many different fat collection and processing methods and systems exist for separating the viable fat cells from the lipoaspirate fluid that contains tumescent fluid, blood, and lipids. These include special collection systems,

fat collection bottles, special filter systems, manual gravity separation, gravity separation with centrifugation, and external straining. After initial decanting, antibiotics and platelet-rich plasma (PRP) may be added to the separated fat prior to additional gravity separation (Figs. 61-5 and 61-6).

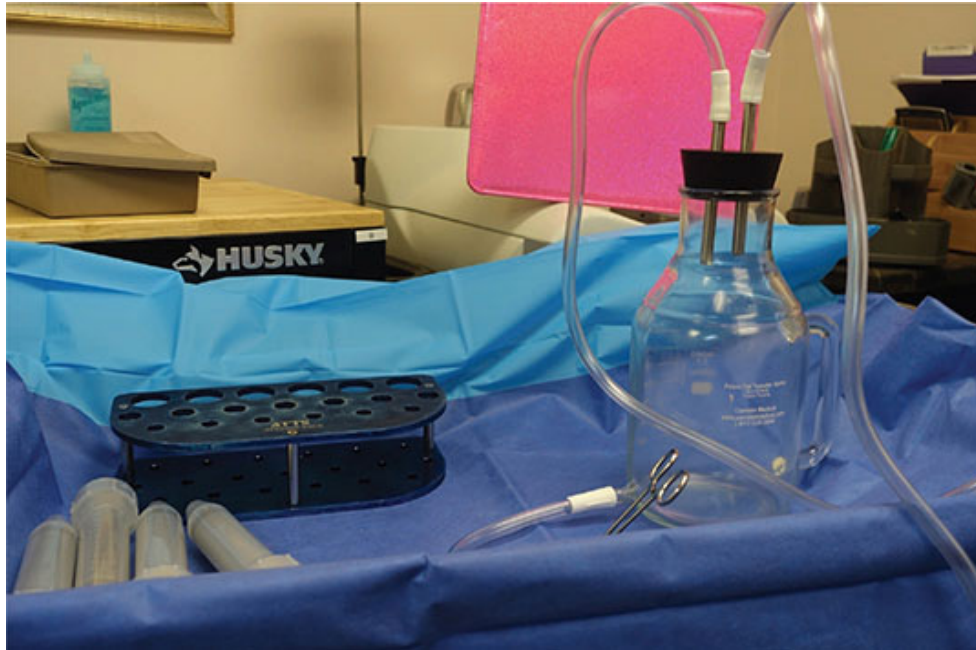


Figure 61-5. A sterile fat collection bottle, sterile syringe stand, and 60-cc Toomey syringes with Toomey adaptors, Toomey plugs, and Toomey cannula are often used for fat grafting to large areas. Toomey to Luer lock adaptors permit transfer of the harvested fat to smaller 1-cc syringes to be used for facial fat transfer. Occasionally the lipoaspirate is strained to obtain a large amount of fat for grafting to a body area. The cannula that is harvesting fat from the patient is directly connected to the top of a sterile fat harvesting bottle which is also connected a disposable fat canister attached to the vacuum pump. After collection the serous fluid separates by gravity from the fat in the lipoaspirate to the bottom of the harvesting bottle. The tubing attached to the lower outlet is unclamped to remove the serous fluid, then reclamped. A Toomey or Luer lock adaptor is connected to the lower outlet tubing, a syringe is attached to the special adaptor, the tubing unclamped, and the separated fat is harvested into syringes to prepare for fat grafting.



Figure 61-6. Sterile fat collection bottle in the process of filling.

Fat extraction from vacuum pump lipoaspirate

A. Gravity separation method:

- a.** First gravity separation: Decantation of serous fluid after gravity separation from sterile container with or without a sterile filter trap.
- b.** Second gravity separation: Gravity-separated fat is withdrawn into separate 60-cc Toomey syringes. Each capped syringe is placed vertically in a syringe rack. After 10 to 30 minutes, the serous fluid is decanted from the Toomey syringes.
- c.** Centrifuged separation: May be performed but may damage the fragile fat cells.
- d.** After separation, the fat for grafting is transferred to large 60-cc Toomey syringes if large areas such as the breasts and buttocks are to be grafted. If facial fat augmentation is planned, a Toomey to Luer lock adaptor is utilized to transfer the fat to individual 1-cc Luer lock syringes. These 1-cc syringes are placed vertically in a small syringe rack (Figs. 61-7 to 61-17).



Figure 61-7. A Toomey adaptor is connected to the lower outlet tubing to prepare for placement in 60-mL Toomey syringes, which are often preferred for body fat grafting because they tend to clog less than Luer syringes.



Figure 61-8. A Toomey syringe is attached to the Toomey adaptor, the tubing unclamped, and the separated fat is harvested into 60-mL syringes to prepare for fat grafting. Harvested fat can also be transferred to Luer lock syringes of different sizes.

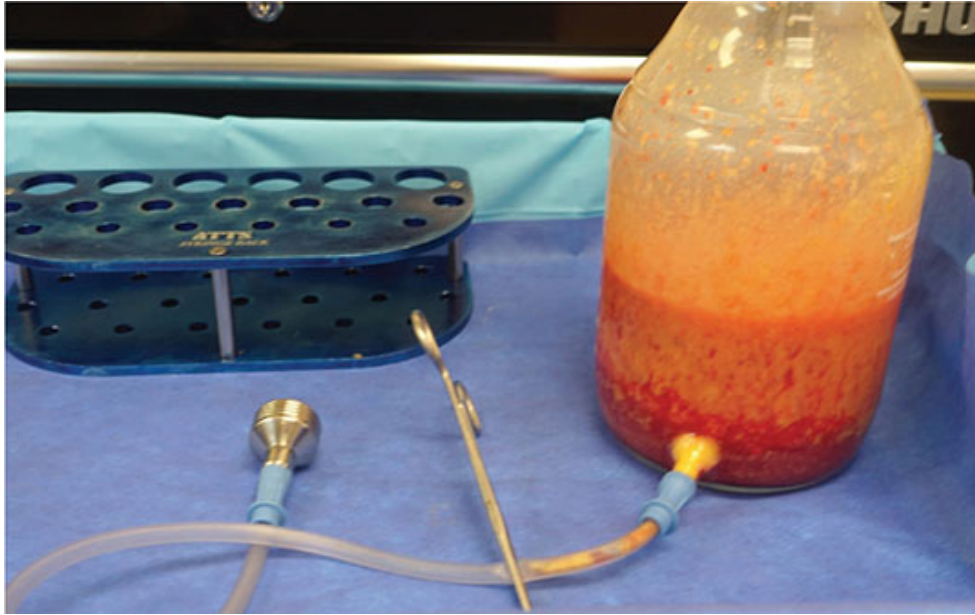


Figure 61-9. First gravity separation—After collection the serous fluid separates by gravity from the fat in the lipoaspirate to the bottom of the harvesting bottle. The lower outlet tubing is unclamped to remove the serous fluid, then reclamped.



Figure 61-10. Preparation of machine-harvested fat for body areas. Harvested fat is transferred to 60-mL Toomey syringes. Harvested fat can also be transferred directly to Luer lock syringes of various sizes.



Figure 61-11. Preparation of machine-harvested fat for grafting to body areas—A Toomey syringe cap is placed at the end of the Toomey syringe prior to placing it vertically in the syringe stand to permit additional gravity separation to take place.



Figure 61-12. The Toomey syringe cap is secured in place.

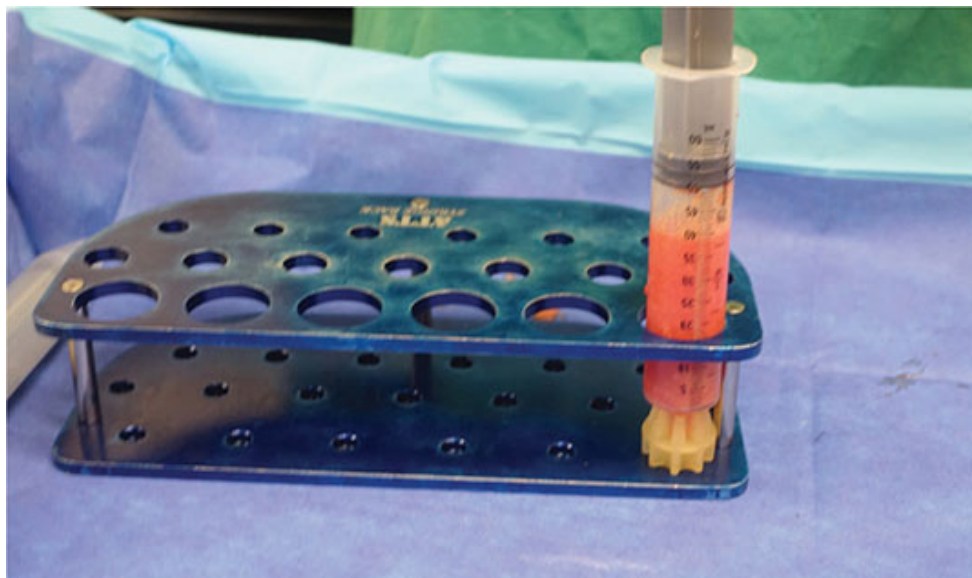


Figure 61-13. The Toomey syringe is placed vertically in the syringe stand to permit gravity separation to take place.

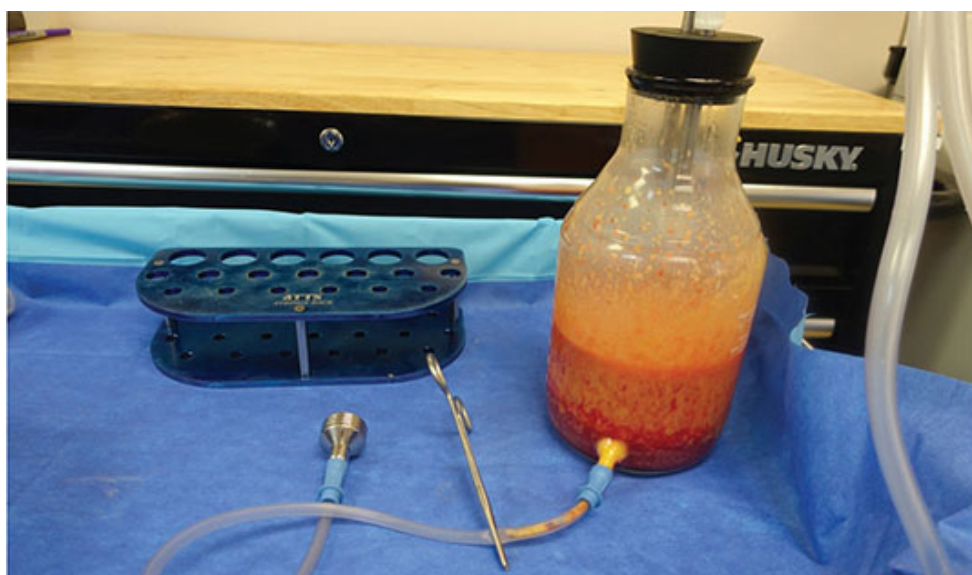


Figure 61-14. Preparation of machine-harvested fat for transfer to body areas: first gravity separation —After collection the serous fluid separates from the fat in the lipoaspirate to the bottom of the harvesting bottle. The tubing attached to the lower outlet can be unclamped to remove the serous fluid, then reclamped.



Figure 61-15. Preparation of machine-harvested fat for transfer to body areas: straining. The lower outlet tubing can be unclamped and the fat can be strained prior to placement into the fat grafting syringes.

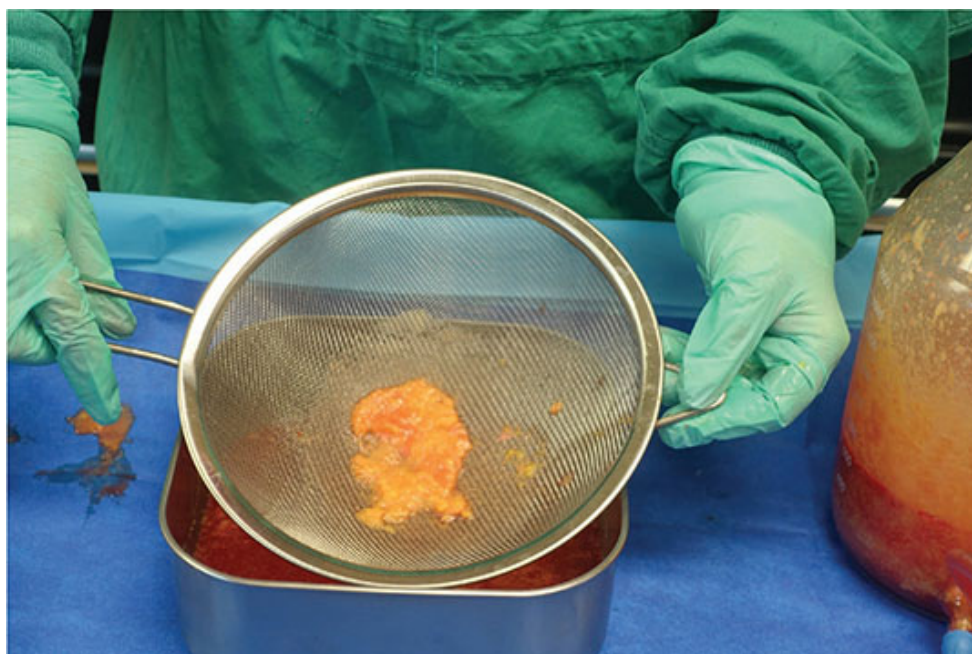


Figure 61-16. Straining harvesting fat—Machine-harvested fat tubing can also be strained to rapidly prepare a large amount of fat for fat grafting to large body areas.

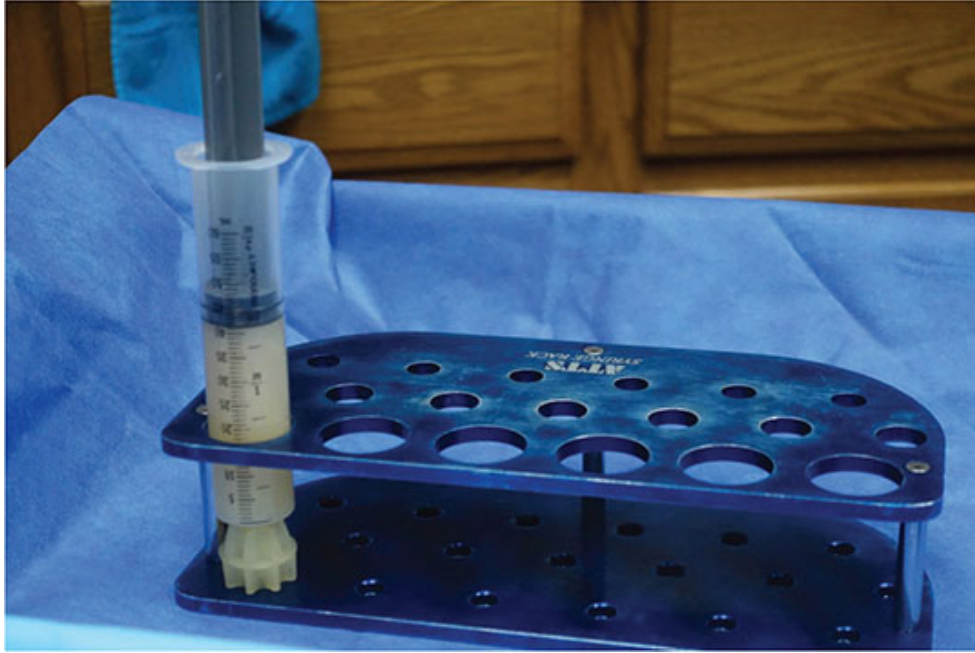


Figure 61-17. Gravity fat harvesting by vacuum pump—A cap is placed at the end of the syringes prior to placing each syringe vertically in the syringe stand. After a Toomey cap is placed on the Toomey syringe, the filled syringe is placed vertically in the syringe stand to permit an additional gravity separation to take place prior to injection.

Fat extraction from syringe lipoaspirate

A. Gravity separation method:

- a.** The 10-cc Luer lock syringes that contain the fat aspirate are capped immediately after fat harvesting and placed vertically in the syringe stand so that gravity separation can occur.
- b.** First gravity separation: Decantation of serous fluid from syringes after separation by gravity.
- c.** Optional centrifugation of syringes or optional placement of fat in special fat extraction device prior to centrifugation.
- d.** For facial fat transfer the fat is placed in individual 1-cc syringes utilizing a Luer to Luer lock adaptor. These 1-cc Luer lock syringes are then placed vertically in a special small syringe rack.
- e.** Second gravity separation decantation of serous fluid is performed if gravity separation of serous fluid occurs in the 1-cc syringes (Figs. 61-18 to 61-21).

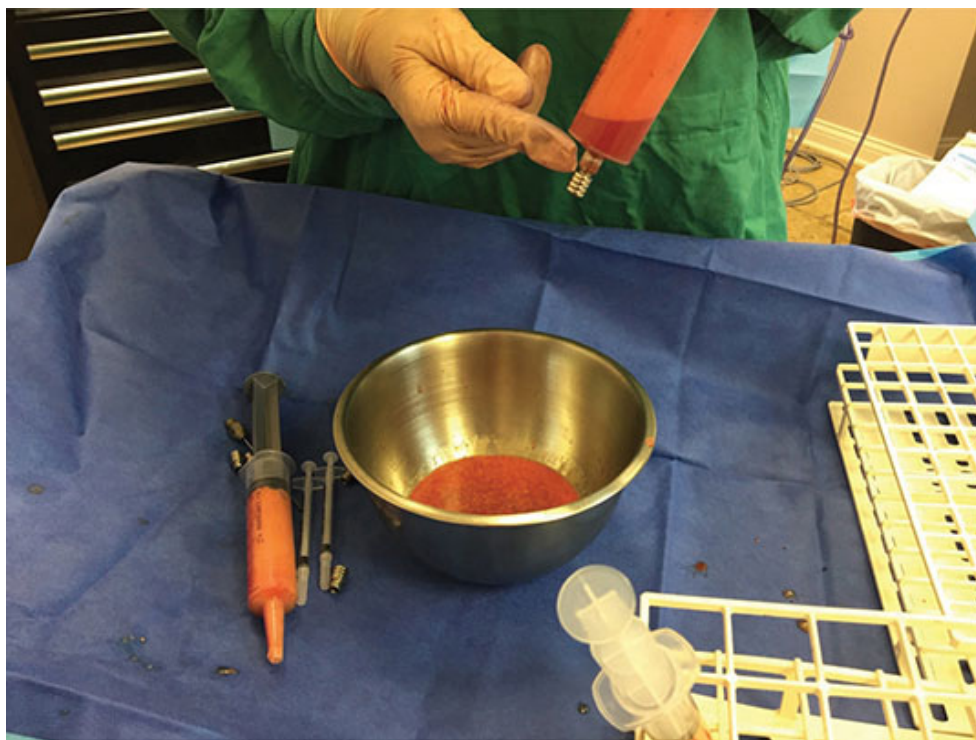


Figure 61-18. Second gravity separation—The serous fluid has separated to the bottom of the syringe. The syringes are permitted to stand for several minutes to allow gravity separation to take place. The syringe cap is removed to drain the serous fluid from the bottom of the syringe prior to fat grafting.

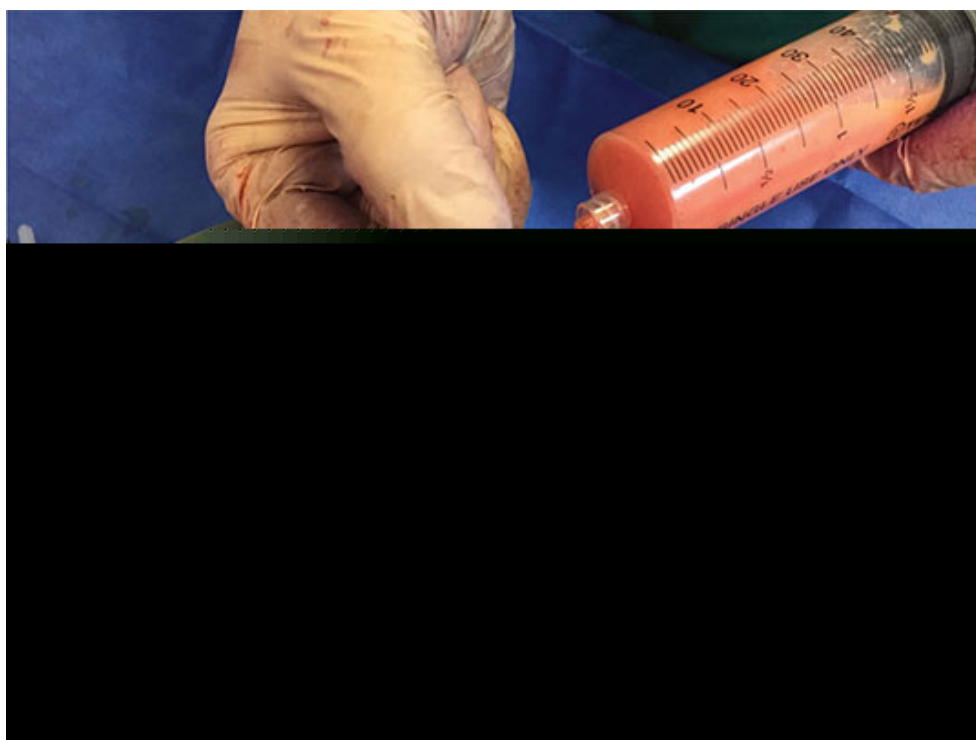




Figure 61-38. The 1-cc syringe is attached securely.



Figure 61-39. Fat is gently drawn into the 1-cc syringe.

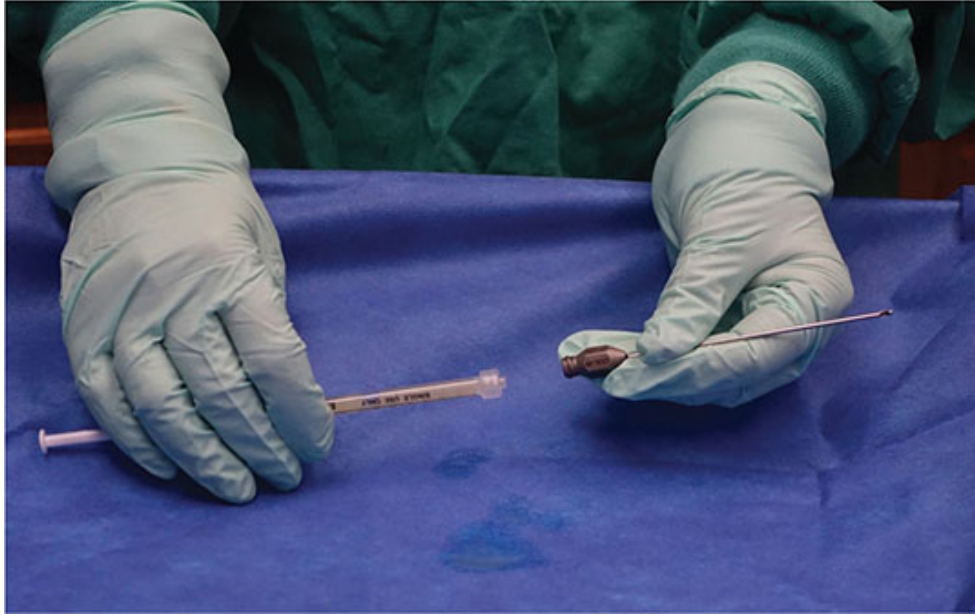


Figure 61-40. Facial fat grafting—A blunt-tipped 2-mm Coleman cannula is attached to the separated fat to prepare for fat grafting to the face.



Figure 61-41. The cannula is secured to the syringe.

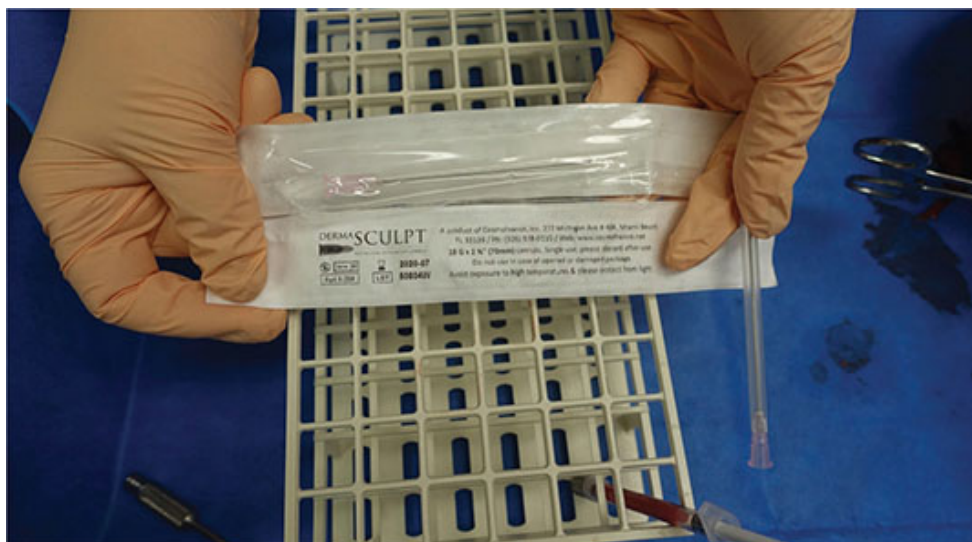


Figure 61-42. Disposable cannula for facial fat grafting—Disposable blunt-tipped single use cannulas can also be used for transfer to the face. The 14-, 16-, and 18-gauge sizes work well for facial fat grafting.



Figure 61-43. Cannula injection entry points are marked—A few injection points, usually three on each side of the face, can be used to inject most areas of the face. Additional entry points can be made if needed to inject specific areas such as the lips, glabella, or nose.



Figure 61-44. Oblique view of cannula entry points.



Figure 61-45. Lateral view of cannula entry points. Note that all earrings are removed prior to starting the procedure.



Figure 61-46. The patient is prepared for the fat transfer procedure.



Figure 61-47. Guiding entry needle for cannula entry point on face—An open entry point for the blunt fat grafting cannula is created by inserting an entry needle 3 to 5 mm into the skin at a 45-degree angle, just prior to grafting fat into the area.



Figure 61-48. Port creation for the mid-face.



Figure 61-49. Port creation for the upper face.



Figure 61-50. Guiding entry needle for cannula entry point on face—An open entry point for the blunt fat grafting cannula is created by inserting an entry needle 3 to 5 mm into the skin, at a 45-degree angle, just prior to grafting fat into a nearby area.



Figure 61-51. Entry point for injections to the lower face—From this lower entry point injection of the prejowl sulcus, melolabial fold, mental crease, and chin can be made.



Figure 61-52. The cannula is advanced gently through the port.



Figure 61-53. The cannula may also be angled upwards towards the cheek.



Figure 61-54. Entry point for injections to the middle face—From this middle entry point injection of the tear trough, nasolabial fold, and middle and lateral cheek can be made.



Figure 61-55. The cannula may also be advanced laterally.



Figure 61-56. The lateral cheek can also be addressed from the middle entry port.



Figure 61-57. The medial cheek and nasolabial folds can be addressed from the middle entry port.



Figure 61-58. The melolabial fold can be addressed as well.



Figure 61-59. The lower entry point may also be used to address the nasolabial folds.



Figure 61-60. The cannula does not need to be removed entirely when changing vectors.



Figure 61-61. The cannula can be gently advanced through the port to augment the lower face.

Fat grafting to the face

Fat transfer can be performed for volume replacement of the entire face, or for the enhancement and correction of specific areas of the face, such as the

lips (Figs. 61-62 and 61-63), perioral region, nasolabial folds, and marionette lines. The planning and techniques utilized to transfer fat to the face are very similar to those used when injecting filler for full volume facial rejuvenation or for enhancement of specific areas of the face. The goal of facial fat grafting is to place very small aliquots of fat, similar in size to a grain of rice, at multiple levels under the skin so that each fat parcel can be easily vascularized by the surrounding capillaries in order to remain viable.



Figure 61-62. Extra entry points for fat grafting the lips—If needed additional cannula entry points can be made to inject specific areas of the face, like the lips and lip corners.



Figure 61-63. Lip augmentation can be performed by changing the cannula vector.

Blunt-tipped cannulas are utilized to place very small amounts of fat at multiple levels below the skin from just a few injection entry points, usually three on each side of the face. If needed, additional entry points can be made to inject specific areas, such as the lips, glabella, or nose. Reusable injection cannulas have been utilized in the past to transfer fat to the face, though disposable cannulas with diameters of 14 gauge, 16 gauge, and 18 gauge are now available and work well for fat grafting to different areas of the face.

Immediately prior to facial fat transfer, a new sterile prep is performed, the patient is placed in the supine position with the head slightly elevated, and new sterile drapes are applied. A sterile 16-gauge disposable cannula is attached to one of the 1-cc Luer lock syringes containing the harvested fat.

After a small bleb of local anesthesia is placed at the first marked entry point, a 14- to 16-gauge Nokor needle is gently inserted into the skin surface at approximately a 25- to 30-degree angle to create an entry port for the blunt-tipped fat grafting cannula. As this larger guiding needle is removed, the injection cannula is advanced through the nascent entry port to the nearby recipient facial area. Prior to injecting the fat, aspiration is performed, and very small parcels of fat, approximately 0.1 cc each, are injected deeply into the recipient area while the cannula is gently withdrawn. Without pulling out completely from the entry point, the fat grafting cannula is then redirected in a

radial fashion in order to place another tiny thread of fat into the treatment area in a similar manner. This grafting procedure is continued in a similar fashion until no more fat remains in the syringe. Each additional syringe is injected into a more superficial plane in the same treatment area in a similar manner until the desired aesthetic shape and volume is obtained. Thus initial fat injections to each new treatment area are usually first injected at a deeper plane, and then subsequent syringes can be gradually placed more superficially. Fat can be placed just above the periosteum initially, followed by additional placement in the more superficial subcutaneous layers of the skin. Occasional resistance may be felt while injecting if a large fat particle clogs the injection cannula. If this occurs, it is important to inspect the syringe for obstructing fat particles instead of trying to force the fat through the cannula to avoid injecting too much fat into one area.

Fat grafting to body areas

Fat grafting is often performed under continuous ultrasonic guidance utilizing an ultrasound system in order to avoid blood vessel penetration and prevent fat embolism (Figs. 61-64 to 61-67).

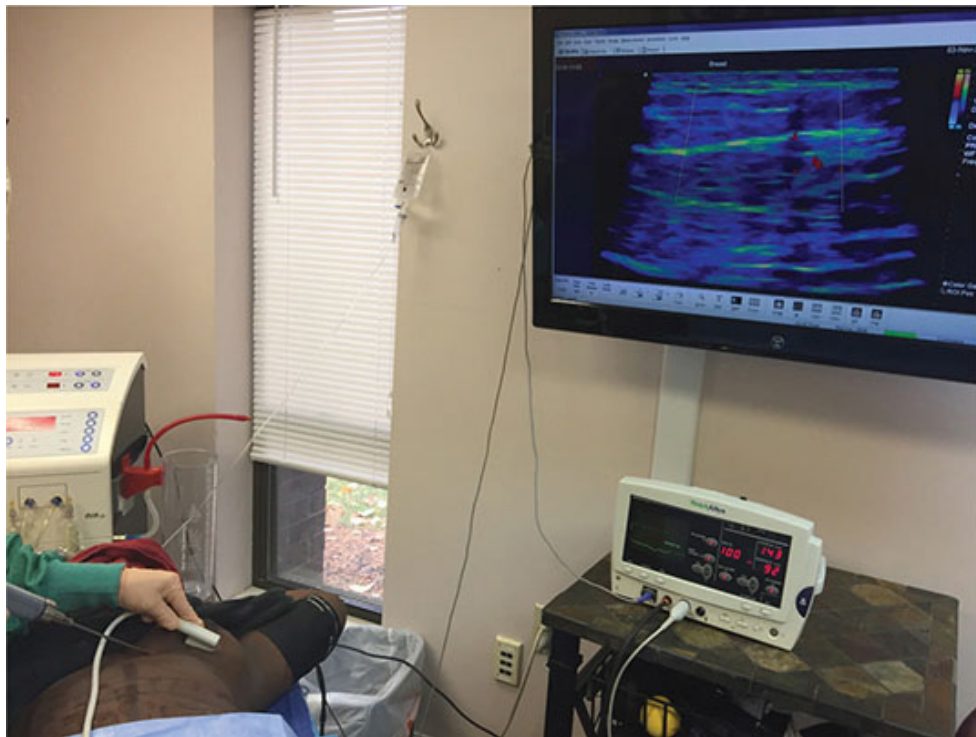


Figure 61-64. Fat grafting to large body areas—Fat transfer to large body areas is performed under continuous ultrasonic guidance in the operating room.

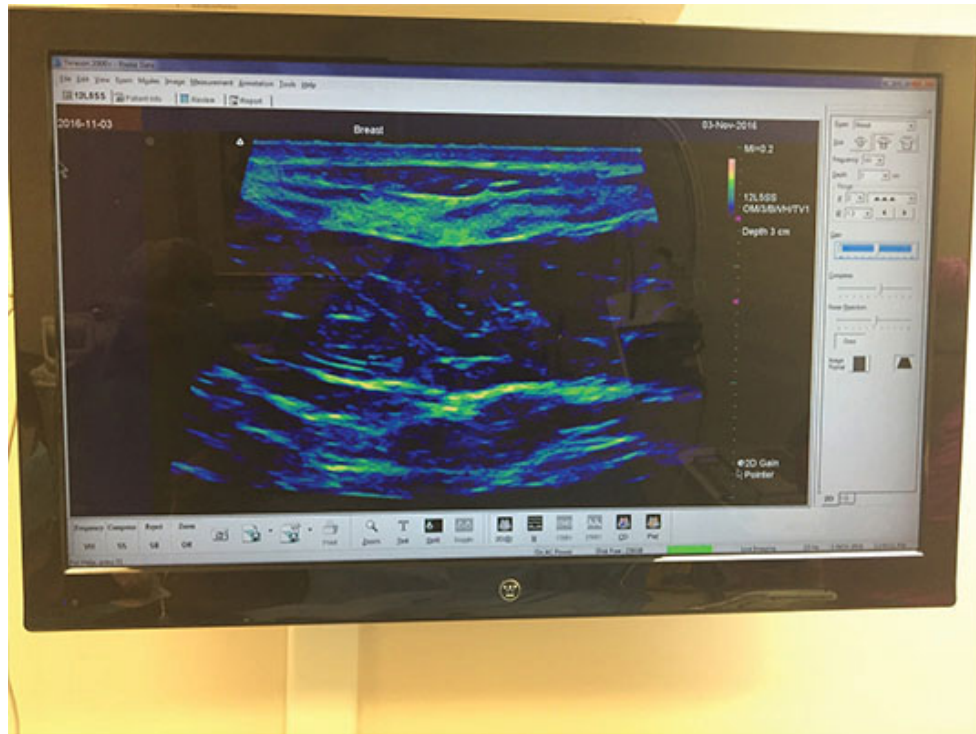


Figure 61-65. Fat grafting to large body areas: breast—An ultrasound image of the breast is viewed on a large television monitor in the operating room for improved visibility.



Figure 61-66. Fat grafting to large body areas: breast—Under ultrasonic guidance, an initial aspiration is made, then small retrograde injections of fat are placed in a radial fashion in the breast as the cannula is slowly withdrawn.

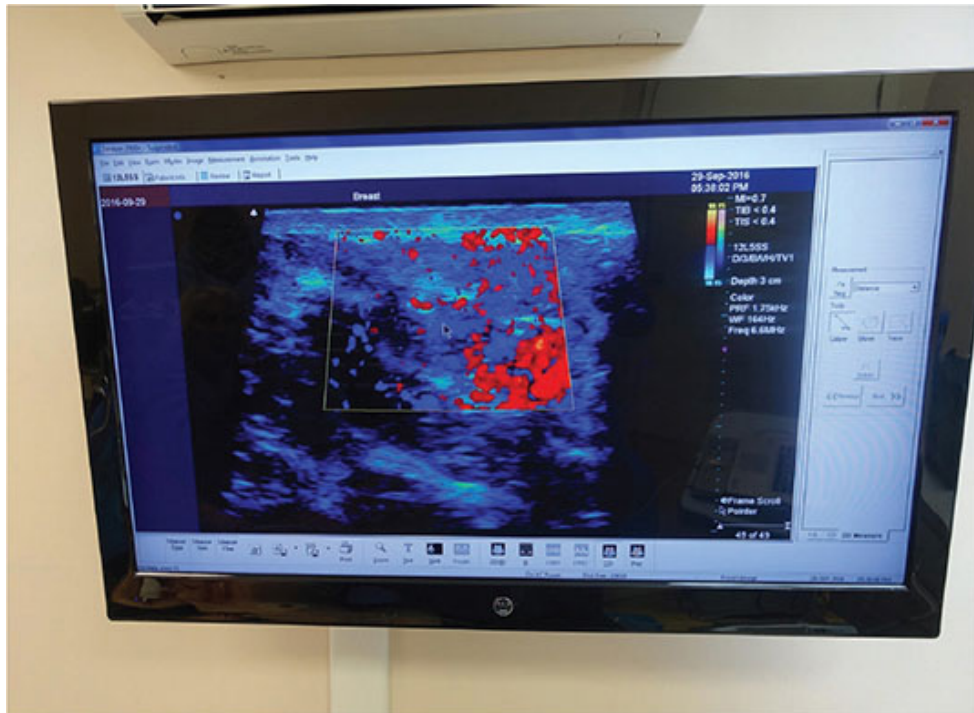


Figure 61-67. The ultrasound image of the recipient site can reveal blood vessel location and detect fat injection.

After the recipient area receives a new sterile preparation and new sterile drapes, the fat transfer is carefully performed superficially in the subcutaneous fat layer utilizing a 2-mm blunt-tip fat transfer cannula attached to a Toomey syringe. Initial aspiration is performed prior to each injection to ensure that the cannula has not entered a blood vessel. The fat is slowly injected in a retrograde fashion as the cannula is slowly withdrawn in order to transfer small 0.25- to 1-cc linear aliquots of autologous fat. When the tip of the cannula approaches the entry port it is redirected radially in a superficial fanning pattern in the same layer of the subcutaneous tissue, and the fat is again injected in a retrograde fashion after initial aspiration, in the same manner as previously described. The fat grafting procedure is continued in different subcutaneous layers of the recipient body area until the desired contour is obtained with the patient observed in the supine, prone, sitting, and standing positions. The amount of fat transferred to each body

area is recorded. After the fat grafting to each recipient body area is completed, the entry points are sutured.

Fat grafting to the buttocks

Prior to performing fat transfer to the buttocks it is important to improve the overall shape of the buttock through carefully planned liposuction. This is done by removing fat from the lower back region, the rear hips, the presacral triangle, and sometimes the inner and outer thighs. Liposuction of these areas alone will result in a more attractive shape to the buttock, with the illusion of increased volume and projection. To avoid injecting fat into the blood vessels located in the buttock, all fat may be injected into the superficial subcutaneous tissue in the buttock instead of into the muscle, under ultrasonic guidance. Most of the transferred fat is placed superiorly at the upper aspect of the gluteus maximus, and some is placed medially in the cheeks near the upper crease of the buttock. Large amounts of fat are often required to increase the projection of the buttocks, typically 300 to 500 cc per side.

Fat grafting to the breasts

Women often request that small amounts of fat be transferred to their breasts in order to improve their shape and fullness. Fat can also be injected into the lower aspect of the breast to create a small breast lift and improve breast ptosis without more invasive surgery.

Breast implants are usually recommended to patients who want a large predictable increase in breast size. For patients who prefer a natural increase of more than one cup in breast size, two fat grafting procedures are usually planned.

Fat grafting to the hands

With aging, the hands appear thinner, and the veins and tendons on the dorsum of the hands become more noticeable. For patients who desire younger looking hands, a small amount of the patient's own fat can be injected to the dorsum of the hand to create more youthful looking hands. For a detailed discussion, see Chapter 84.

Fat grafting for cellulite

Body areas that have cellulite often show improvement after the release of each deep adhesion with a Toledo V- dissector, followed by fat grafting to

each separate depression. A certain amount of overfilling is recommended to allow for some fat resorption.

Fat grafting for high definition liposculpting

After performing liposuction to increase muscle definition, small amounts of fat can be transferred to the male chest to improve the muscle definition of the pectoralis muscles, and to improve the prominence of the ridges of the rectus abdominis muscles of the abdomen.

Fat grafting for postsurgical defects, depressions, and scars

Depressed and retracted surgical scars often show great improvement when they are undermined and freed of the excess fibrous attachments with a Toledo V-dissector, followed by fat grafting to the area. Usually, only a small amount of fat is needed, and slight overfilling is recommended. For the physician new to fat grafting, filling these surgical defects and post liposuction depressions with transferred fat is an excellent way to develop confidence and skill in fat grafting techniques (Figs. 61-68 to 61-74).



Figure 61-68. Fat grafting for depressions and scars—A depression and irregular areolar border occurred on the patient's left breast after breast reconstruction. After local tumescence, the area under the depression was gently undermined with the V-dissector and approximately 20 cc of autologous fat was transferred to the area. Dry, flaking skin is present after the dressing was removed at patient's 2-week postoperative visit.



Figure 61-69. Fat grafting for postsurgical defects, depressions, and scars: fat transfer after melanoma excision—Fat was transferred to the deep depression on the left medial thigh that remained 3 years after melanoma was excised. The area was tumesced, and a Toledo V-dissector was used to free the fibrous scar tissue prior to grafting 30 cc of fat to the area.

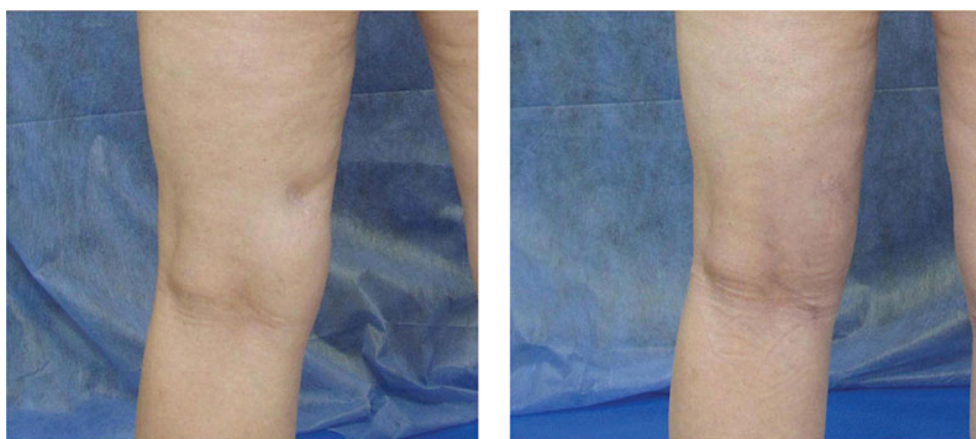


Figure 61-70. Fat grafting for postsurgical defects, depressions, and scars: fat transfer after melanoma excision—Rear views of the upper leg of the same patient shown in Figure 61-69.

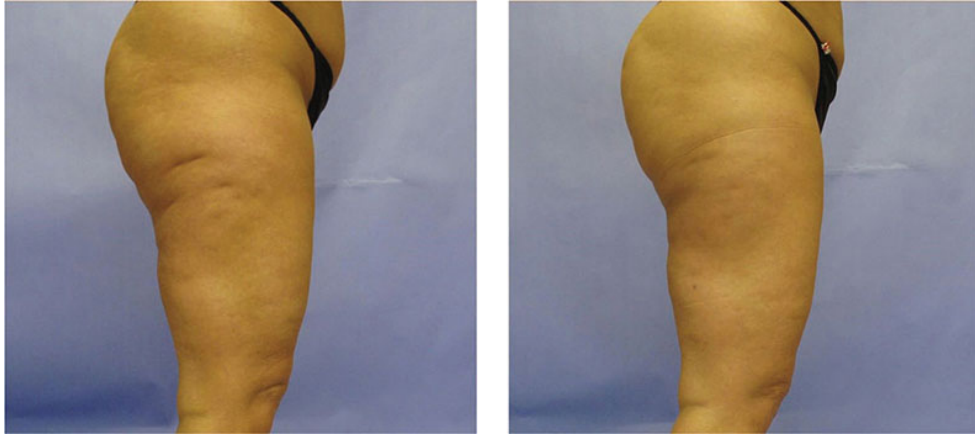


Figure 61-71. Fat grafting for dents and depressions of cellulite—Fat was transferred to the deep depressions on the lateral thighs that naturally occurred after an increase in cellulite after weight gain.

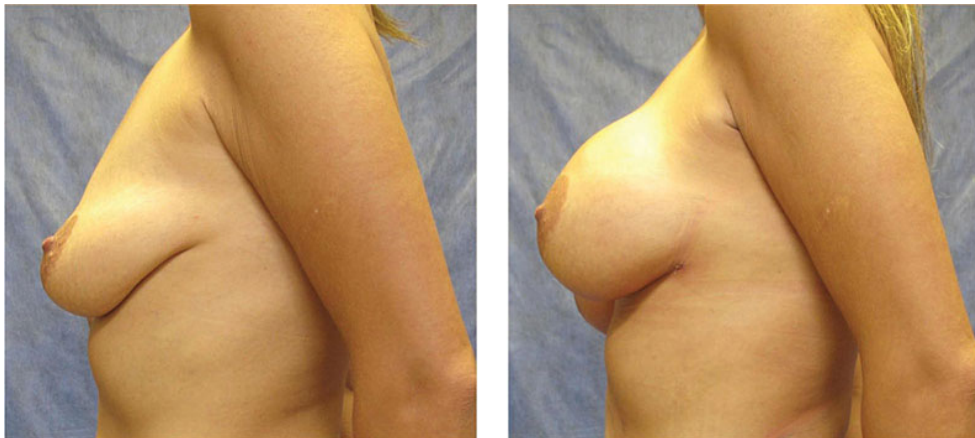


Figure 61-72. Fat grafting to the breast—Fat grafting was performed to both breasts in the 36-year-old woman with marked breast atrophy and ptosis after weight loss. Although implants with a breast lift were recommended, the patient preferred fat grafting.



Figure 61-73. Fat grafting to the buttocks—Improved contour with slight increase in size of the buttock after a small fat transfer to the buttocks in a thin patient.

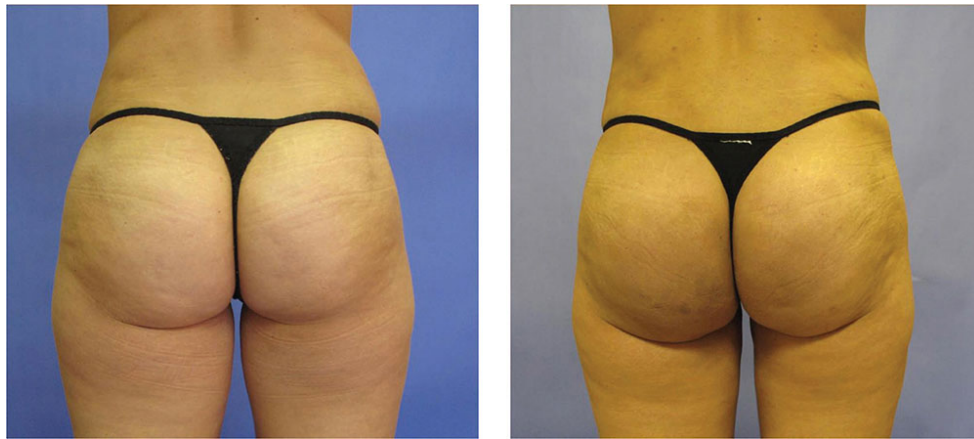


Figure 61-74. Fat grafting to the buttocks—Rear views of the buttocks of the same patient shown in Figure 61-73.

Postoperative care

Compression garments are recommended over the donor sites for several weeks, but it is important to avoid compression over the recipient sites. Specially designed body compression garments are available for use after buttock augmentation, and special supportive bras with minimal compression are advised after fat grafting to the breast.

Patients are advised to be gentle with all areas that have received fat grafts, to avoid massage and manipulation of these areas, and to avoid strenuous physical activity for 2 weeks. It is also important to maintain a stable weight and avoid excessive weight loss or weight gain after fat transfer has been performed (Figs. 61-75 to 61-80).



Figure 61-75. Fat grafting to the face—Fat was transferred to the lips, chin, melolabial lines, nasolabial folds, cheeks, nasojugal groove, and tear trough. Areas were not overfilled because the patient needed to return to work within 1 week.



Figure 61-76. Fat grafting to the face—Right three-quarter views of the same patient shown in Figure 61-75.



Figure 61-77. Fat grafting to the face—Left three-quarter views of the same patient shown in Figure 61-75.



Figure 61-78. Fat grafting to the face—Fat was transferred to the smile lines only. Areas were not overfilled per patient request because she needed to return to work within 1 week.



Figure 61-79. Fat grafting to the face—Right three-quarter views of the same patient shown in Figure 61-78.

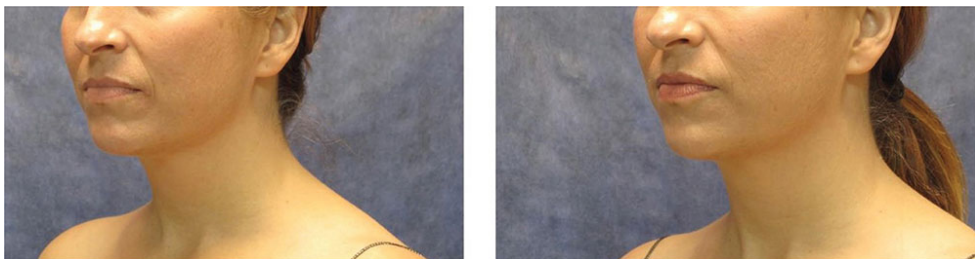


Figure 61-80. Fat grafting to the face—Left three-quarter views of the same patient shown in Figure 61-78.

Postoperative visits are usually scheduled for the day after surgery, then weekly for the first month; further visits depend on individual circumstances.

Postoperative care after facial fat transfer

After facial fat transfer, the patient is advised to sleep with their head elevated on two pillows for several weeks. Ice packs may be applied throughout the day for the first 2 days. Patients are instructed to avoid doing housework and bending over to prevent increased swelling. Antibiotics, a

steroid taper, and HSV prophylaxis are often prescribed, and patients are advised to avoid all dental procedures for 1 month.

Side effects and complications

Side effects of facial fat transfer

Facial edema is to be expected after facial fat grafting, and the amount of swelling depends upon the amount of fat that was grafted. A large amount of edema often occurs after fat transfer to the infraorbital area. Most of this edema improves after 4 days, though it can last 8 to 14 days, and a small amount of swelling can persist for up to 3 months.

Small ecchymoses may occur but are infrequent if cannulas are used to perform the injections. A reactivation of herpes labialis may occur. The cervical lymph nodes may become enlarged after the procedure.

Complications after fat grafting are similar to those that can occur after liposuction, and include seromas, skin surface irregularities, anemia, induration, liquefied fat necrosis, infection, asymmetry, and fat embolism.

Lumps and bulges may occur due to persistent edema, and may also occur if the fat was placed too superficially, especially in the infraorbital area. They are also common in the context of overcorrection. Management includes careful observation for several months and intralesional steroid injection. After 6 months, a small liposuction procedure can be performed for cases of true overcorrection.

Undercorrection may be apparent after fat transfer even if the proper amount of fat was grafted, due to variability in fat resorption in a particular body area, excess external pressure from clothing, habits, or body position, or due to an individual's personal physiology. It can easily be corrected by a repeat procedure that is usually scheduled after waiting 6 months.

Fat storage

Many surgeons and patients are eager to store excess fat for future transfer, as the quantity of fat that is removed after a single liposuction session is often far in excess of what would be typically transferred on 1 day, especially when the patient is only interested in facial augmentation. Despite the

temptation to utilize frozen fat, some evidence has suggested that fat that is simply frozen and stored at -20°C may result in no viable cultures after a single freeze–thaw cycle unless cryoprotectants are used. Therefore, this approach should probably not be used on a routine basis (Figs. 61-81 to 61-86).



Figure 61-81. Fat grafting to the face—4 days after submental liposuction and a small transfer of 4 cc of fat to patient's lower perioral area and melolabial folds. The patient wanted a short recovery and requested that only a small amount of fat be transferred.



Figure 61-82. Fat grafting to the face—Frontal views of the same patient shown in Figure 61-81.



Figure 61-83. Fat grafting to the face—Right profile views of the same patient shown in Figure 61-81.



Figure 61-84. Fat grafting to the face—Left profile views of the same patient shown in Figure 61-81.



Figure 61-85. Fat grafting to the face—A small fat transfer was performed to the lips of this 73-year-old woman per patient request because she wanted only slightly bigger lips. Before (left) and 3 weeks after (right) procedure.



Figure 61-86. Fat grafting to the face—Left three-quarter views of the same patient shown in Figure 61-85 before (left) and 3 weeks after (right) procedure.

CONCLUSIONS

Fat represents an outstanding filler, and large amounts of fat for transfer are often available, particularly if the surgeon routinely performs liposuction. With proper technique, 70% to 80% viability of grafted fat cells is possible. The final results after fat grafting may be unpredictable, though the beneficial final results that are obtained are generally long lasting, and this approach represents a technical and artistic procedure that continues to evolve.

CHAPTER 62 Hair Transplantation

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Nilofer Farjo
Greg Williams



SUMMARY

- Androgenetic alopecia, or pattern hair loss, is the most common cause of hair loss in both men and women, and the most common indication for hair transplant surgery.
- There are two basic methods of donor area harvesting: follicular unit extraction (FUE) and strip follicular unit transplantation techniques (strip FUT).

Beginner Pearls



- Hairline design merits precise attention to detail as it will come under the closest scrutiny from the patient and be most visible to observers.
- In a completely bald area, a single procedure can achieve up to 25% to 30% of the original density; thus, patients often require two procedures to achieve a cosmetically desirable density.
- The biggest mistake that is made by beginner hair restoration surgeons is choosing the wrong patient.

Expert Pearls



- The safe donor area for FUE is generally the same as for strip FUT. However, the harvesting can be extended to other areas, such as the lower neck, if the chance of future loss is remote.
- The trichophytic closure technique may help disguise the strip donor scar. A very superficial string of epidermis (1×1 mm) is removed all along the lower or upper wound edge ahead of closure. This has the effect of forcing hairs from this trimmed edge to grow through the scar, breaking up its linear appearance.

Don't Forget!



- FUE uses two basic punch types with sharp and blunt tips; each has manual and power versions.
- Combining strip FUT and FUE can be considered to maximize the number of grafts obtained from a single procedure.
- Generally this approach may increase the single surgery yield by up to 50%.

Pitfalls and Cautions



- It is imperative that grafts are placed in an appropriate storage solution as they await placement back into the scalp. They are very susceptible to trauma and desiccation, and this is probably one of the most common contributors to disappointing growth with inexperienced operators.
- While much time is spent by patients and surgeons debating the merits of different donor harvesting techniques, it is the skill and artistry involved in the incision site creation and graft placement that ultimately determines the aesthetic appearance of a hair transplant.

Patient Education Points



- The patient can wash the donor site the next day, and normal washing of the grafted area can resume after 1 week.
- Most surgeons recommend frequent misting of the recipient area with a saline-based solution over the first few days.
- From 7 to 10 days postoperatively, the majority of grafts will start to shed their surface crust and probably the external hair shaft as well. New hairs will start to grow after 3 to 4 months, but will not reach maturity demonstrating the final result until 8 to 14 months from the date of the procedure.

CHAPTER 62 Hair

Transplantation

INTRODUCTION

Androgenetic alopecia, or pattern hair loss, is the most common cause of hair loss in both men and women, and the most common indication for hair transplant surgery.

There are many other causes of alopecia, such as metabolic conditions (diabetes, thyroid disease, anemia), telogen effluvium, scarring and traction alopecia, drugs, trauma, and autoimmune conditions. Some of these conditions are amenable to hair transplant surgery, though surgical intervention is contraindicated when an underlying disorder remains active. With any type of hair loss, the first step is to confirm the diagnosis before treatment can be considered. This is particularly important in women, in whom female pattern hair loss is a diagnosis of exclusion (Fig. 62-1).

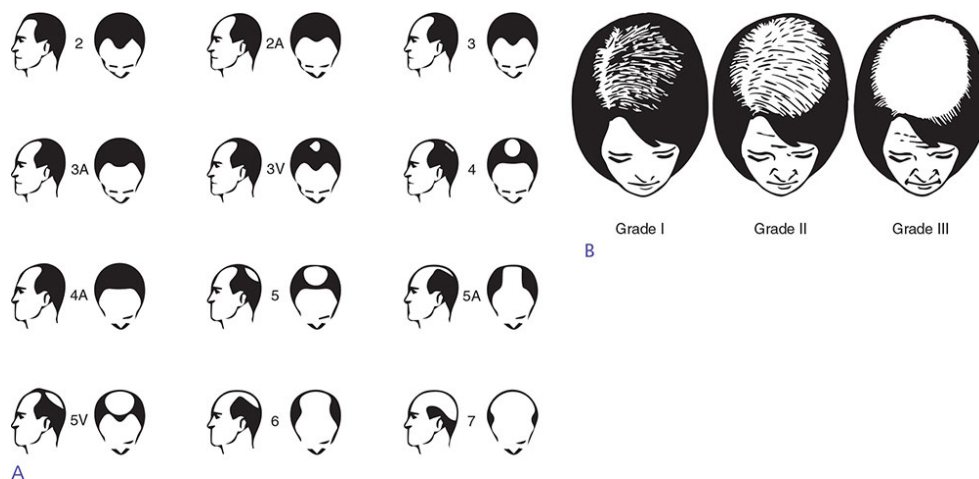


Figure 62-1. (A) Norwood classification of male pattern baldness. (B) Ludwig classification of female pattern hair loss.

TECHNIQUES

Modern hair transplantation techniques involve follicular unit grafting, a process in which the natural grouping of hairs is preserved. Most hairs are grouped as two, three, or four hairs in a close bunch surrounded by a sebaceous gland and attached to one arrector pili muscle. There are also a small number of single hairs that grow on their own. During surgical restoration, retaining these natural groupings not only produces the most natural looking results but also the best graft survival rates.

There are two basic methods of donor area harvesting: follicular unit extraction (FUE) and strip follicular unit transplantation techniques (strip FUT).

Strip FUT harvesting involves removing a narrow but long strip of hair-bearing skin excised from a dense area of the donor scalp. The patient’s hair above the donor site completely covers the closed donor area so that at the end of the surgery the patient can leave with the most cosmetically pleasing appearance. The harvested strip is dissected microscopically into individual follicular unit grafts. The procedure usually requires a significant number of skilled technical staff with, on average, one experienced technician per 500 grafts (Table 62-1 and Figs. 62-2 and 62-3).

Table 62-1. Indications for Strip FUT Surgery

Patient Preference
Unwilling to shave the donor site
Donor area size limitation
Advanced baldness
Financial or time limitation
Females

Table 62-2. Indications for FUE Surgery

Patient preference
Hair character, spiky with obtuse exit angle
Short or cropped hairstyle
History of scarring
Tight scalp
Young patient with uncertain hair loss future

Table 62-3. Patient Selection

Expectations	30% of Original Density per Procedure
Age	>25
Norwood scale	≥Norwood III
Family history	PGF, F, MGF Norwood V or >
Hair characteristics/ contrast with skin color	High contrast = less result



Figure 62-2. Typical postoperative appearance of strip FUT harvesting method.



A



B

Figure 62-3. Typical strip FUT technicians' setup.

FUE is a method whereby punches of various types are used to remove follicular unit grafts from the donor region individually. The main advantages to patients are the lack of a linear scar and faster healing of the donor area.

This technique should allow patients to maintain a short haircut of only a few millimeters or less in the long term. FUE also allows the surgeon to harvest grafts where there is limited scalp elasticity ([Table 62-2](#) and [Fig. 62-4](#)).



Figure 62-4. Typical postoperative appearance of FUE harvesting method.

In a completely bald area, a single procedure can achieve up to 25% to 30% of the original density; thus, patients often require two procedures to achieve a cosmetically desirable density. In areas that are not completely bald, it is important to try to control ongoing hair loss with medical treatment; otherwise the patient may not look any different after a transplant as they continue to lose hair. If hair loss is genetically mediated, then results should be long lasting, though in other situations, if hair is lost due to a relapsing medical condition such as alopecia areata, then transplantation cannot be guaranteed. For some patients, even a temporary return to “normal” hair is acceptable.

PATIENT SELECTION

When selecting a suitable patient for transplantation it is important to take a number of factors into account ([Table 62-3](#)). The biggest mistake that is made

by beginner hair restoration surgeons is choosing the wrong patient. Because hair loss is a lifelong process it is vitally important to expect future hair loss and plan the procedure on that basis. Patients may or may not continue with nonsurgical treatments to maintain their hair for the rest of their life. Regardless, at some stage they may suffer additional hair loss, and so patients should never be told that a single procedure will lead to complete and permanent improvement. The ongoing challenge with hair transplant surgery is the finite amount of hair available to work with that can only diminish, while the “canvas” to work on can only become larger.

The first consideration to take into account is the patient’s age. Those who are very young and/or in the early stages of hair loss may request surgery without appreciating its long-term consequences. A strong family history of balding should reinforce caution with anyone under 25 years of age as they have more time to lose significantly more hair (Fig. 62-5). With respect to Norwood classification, only those with Stage III or above should be offered surgery, and even in that situation the other factors such as age and family history should be considered (Fig. 62-1).



Figure 62-5. Example of a patient too young and with too early a hair loss stage to consider surgery.

Other factors include hair color and quality and skin color. The higher the contrast between hair and skin color the more hairs are needed for coverage. For example, a patient with dark brown hair and light white skin will still have white skin showing through after surgery, while a patient with blond hair and white skin will not. Other hair characteristics such as coarseness and curl will also play a role in the amount of coverage achieved.

CONTRAINDICATIONS

The same considerations should be taken into account as for any other dermatologic surgery procedure. In addition, hair transplant procedures usually take several hours to perform, and patients should be assessed medically on that basis. Given the need for extensive local anesthesia and hemostasis, cardiovascular stability should be established as well. Bleeding diatheses and the use of antiplatelet medications pose a particular hazard in hair transplant surgery due to the thousands of open recipient sites created in the scalp.

HAIRLINE DESIGN

Designing the hairline and determining its position are probably the most important aspects of the procedure. There are a number of guidelines that can be used to choose the appropriate design irrespective of future hair loss.

First, determine the location of the trichion, or the lowest most central point of the hairline. The most reliable method determines the meeting point of the vertical plane over the forehead with the horizontal plane over the scalp. This can be viewed most clearly from a side profile of the patient, but can also be felt by sliding the thumb upward along the forehead until it suddenly slips and gives way; this was described by Sandoval as the shingling point (Fig. 62-6). In most males, this is approximately 7 to 8 cm from the glabella, and about 6 cm from the glabella in females. From this point, the hairline curves upward on either side to blend into a vertical line running through the lateral canthus (Fig. 62-7). From this point, a flare may be designed to curve downward and laterally anterior to the upper temporal hairline. Extreme caution should be exercised if the patient has potential for future hair loss in this area, as this could appear unnatural. Beginners are best advised to avoid this latter design element. The hairs within the above design normally grow in a forward direction, while the ones joining the temporal hairline grow downward and posteriorly, as well as at a more acute angle. Lower and flatter hairlines may look unnatural and unbalanced in the future if the patient has the potential to progress to advanced male pattern baldness. It is important to adhere to the above guidelines until the practitioner attains sufficient experience.



Figure 62-6. Determining the “shingling” point (*red arrow*).

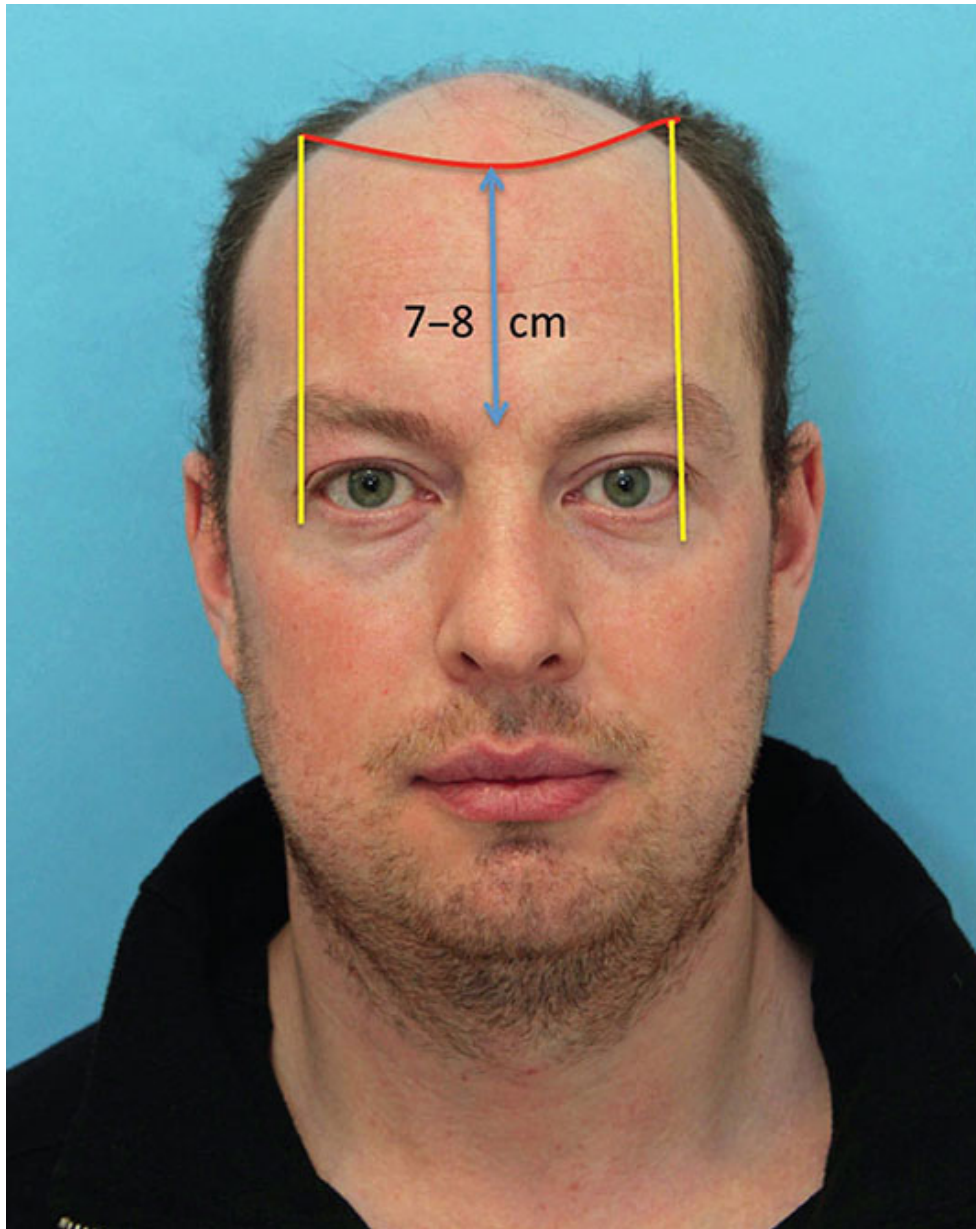


Figure 62-7. Frontal hairline landmarks.

PREOPERATIVE PREPARATION

Prior to the patient arriving for surgery, they should follow several instructions. Both chronic heavy consumption of alcohol and acute intoxication prolong bleeding time and impair platelet function. Patients should be instructed to refrain from alcohol for 24 hours pre- as well as postoperatively. Vitamin E inhibits platelet aggregation, as do some herbal

remedies such as garlic. These should be stopped 7 to 10 days preoperatively. If the patient has a tight scalp and they are having strip excision, they should perform scalp massage at least 1 month preoperatively to increase laxity. On the day of surgery, have the patient wear comfortable clothing as well as a shirt that does not need to be pulled over their head as this could dislodge grafts in the recipient area. At the consultation, any scalp conditions should be assessed and treated where necessary, such as psoriasis and seborrheic dermatitis. A second preoperative evaluation of an underlying scalp condition may be required in some cases.

SAFE DONOR AREA

Grafts should only be taken from areas with terminal hairs that are unlikely to be lost in the future due to continued male pattern hair loss and where the donor scar can be easily hidden. While these locations vary between individuals, there are generally accepted and classically described guidelines. The upper border should ideally be 2 cm below where the balding crown is expected to end in advanced androgenetic alopecia. The lower border should be approximately 2 cm above the hair at the nape of the neck (Fig. 62-8A).



Figure 62-8. (A) “Safe Donor Area” in the occipital scalp. (B) “Safe Donor Area” in the parietal scalp.

On either side laterally it is best to stay behind a perpendicular line passing through the external auditory meatus. Caution should also be exercised around the postauricular area where skin laxity tends to be lower, and therefore a narrower strip width is advised (Fig. 62-8B).

The maximum possible length of the strip usually ranges from 24 to 32 cm, depending on the size of the patient's head. The width (height) that can be excised depends on scalp laxity, and varies from 1 to 2.5 cm, with 1.3 cm as the average. Although there are formulas and devices for this, most surgeons will estimate potential removable width by squeezing the scalp between fingers or moving the sides of the scalp up and down.

The safe donor area for FUE is generally the same as for strip FUT. However, the harvesting can be extended to other areas, such as the lower neck, if the chance of future loss is remote. Attention needs to be paid to future potential of retrograde alopecia from the neck upward in genetically susceptible patients. Although scarring from FUE is more subtle, and its exposure is potentially less impactful, paying heed to the above safe donor guidelines is still recommended, though with perhaps a little more leeway (Fig. 62-4).

Donor area calculations

In strip FUT, the number of grafts obtainable per square centimeter can be calculated using a densitometer or other similar magnifying device, though no method is absolutely precise. A simple assumption can be made that every 6-cm long and 1-cm wide strip will yield approximately 500 grafts based on an average density of 80 follicular units/cm². This figure can be adjusted with significantly higher or lower donor densities that will vary between individuals and different zones of the donor scalp.

In the case of a preexisting strip donor scar, it is preferable to excise the scar within the new donor strip and replace one scar with another. This will affect the graft yield, and numbers need to be adjusted accordingly depending on the width of the previous scar.

With the patient either sitting up or prone, the donor site hair to be removed is trimmed to a length of 3 to 4 mm. This length will help guide the correct direction of the grafts during their insertion into the recipient sites.

Leaving the hair longer outside the strip will help hide the donor site immediately postoperatively (Fig. 62-2).

One challenge with FUE is the need to shave the donor area ahead of harvesting. This allows the surgeon to extract evenly over the entire donor area to avoid pockets or thin areas. The safe donor zone in the estimation of the surgeon needs to be marked out on the scalp prior to shaving the hair in order to realistically assess the likely “permanent” hairs. The aim is to target 15% to 20% of the follicular units to harvest per procedure. In the patient with an average of 80 units per square centimeter, this translates into approximately 15 harvested units. In patients with potential for significant androgenetic alopecia in the vertex, this is the equivalent of an available safe area of about 180 cm², generating a total of up to 2,700 grafts that may be harvested in a single procedure.

ANESTHESIA

Local anesthesia is normally performed in a ring block around the donor and recipient regions, taking advantage of the landmark position of the donor occipital protuberance to block the greater occipital nerve on either side. Typically 1% lidocaine is used combined with 1:100,000 epinephrine followed by longer acting bupivacaine.

An alternative is to utilize nerve blocks in the frontal recipient area, though patients often find this a very painful process in supraorbital/supratrochlear blocks. In the recipient area, the “Abassi” solution can be used to achieve both tumescence and hemostasis as well as potentially prevent significant postoperative edema (Table 62-4).

Table 62-4. Abassi Tumescence Solution

100-mL bag of sterile saline
Add: 1 mL 1:1,000 epinephrine
Add: 1 mL 40mg/mL triamcinolone

HARVESTING TECHNIQUE

With strip FUT, the key is to visualize the hairs and remain parallel to the exiting hair shafts to help ensure a very low transection rate. A moderate amount of magnification is helpful. A no. 15 blade can be used to incise the epidermis, and for deep scoring the upper and lower strip borders (Fig. 62-9).



Figure 62-9. Scoring the lower border of the FUT strip using a no. 15 blade.

Next, a spreader device (Fig. 62-10), or gentle skin hooks are placed on either side of the incision, and traction is applied (Fig. 62-11). The surgeon holds the upper hook while the assistant holds the lower one and uses the scalpel blade to gently ease through the subcutaneous fat under the follicles while pulling on the strip with tooth forceps or a towel clamp. The goal is to bluntly dissect as much as possible avoiding hair follicle transection and damage to the deep neurovascular bundles.



Figure 62-10. Strip harvesting spreader device designed by Dr. Robert Haber.



Figure 62-11. (A) Use of skin hooks to achieve blunt dissection. (B) The strip is dissected from the subcutaneous fat bluntly with gentle use of the blade and traction. (C) Typical portion of the excised strip with hairs intact.

The above strategy normally results in minimal bleeding, though hemostasis can be achieved with a 4-0 suture or conservative cautery. The use of aggressive electrocautery to stop bleeding will potentially damage nearby hair follicles and contribute to further scarring. Closure of the donor wound is most commonly performed with a continuous 4-0 or 3-0 suture of choice or staples. It is important to pay attention to correct alignment of the hairs on either edge of the wound to ensure a subtle postoperative scar.

The trichophytic closure technique may help disguise the strip donor scar. A very superficial string of epidermis (1×1 mm) is removed all along the lower or upper wound edge ahead of closure. This has the effect of forcing hairs from this trimmed edge to grow through the scar, breaking up its linear appearance (Figs. 62-12 and 62-13).

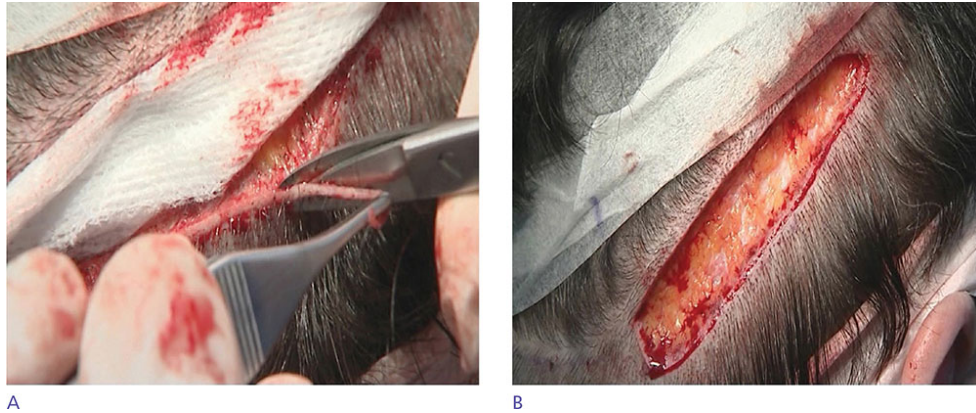


Figure 62-12. (A) Trichophytic closure technique showing removal of epidermis. (B) Donor wound after “lower ledge” epidermis removal.



Figure 62-13. Excellent disguise of linear strip donor scar using the trichophytic closure technique.

FUE uses two basic punch types with sharp and blunt tips; each has manual and power versions. The sharp punches have a shallower depth control to lower the risk of hair transection at the lower end of the follicular unit. The blunt punch permits deeper dissection and more release of the underlying tissue, lowering the force needed for graft plucking or removal.

The key to the use of a sharp punch is depth limitation, usually accomplished with a silicon tube or tape marking on the punch or other design features of the punch handle. The depth may be variable, but typically must be at least as deep as the arrector pili muscle at 2.5 mm or more while keeping the follicles intact. The hairs usually splay beyond the punch area, resulting in higher transection rates. The punch must be accurately targeted while stabilizing the follicles to reduce follicular damage.

The skin is usually injected with tumescent solution, and the punch is aimed so that the emerging hair is centrally located and the angle matches the emergence of the hair. The most common sizes for FUE punches are 0.75 to 1.05 mm. There are considerable number of devices and brands available depending on user preference, including some that have suction devices to assist in lifting the grafts off the skin surface. Examples of sharp systems include the Cole, Ertip, and SmartGraft systems (Fig. 62-14).

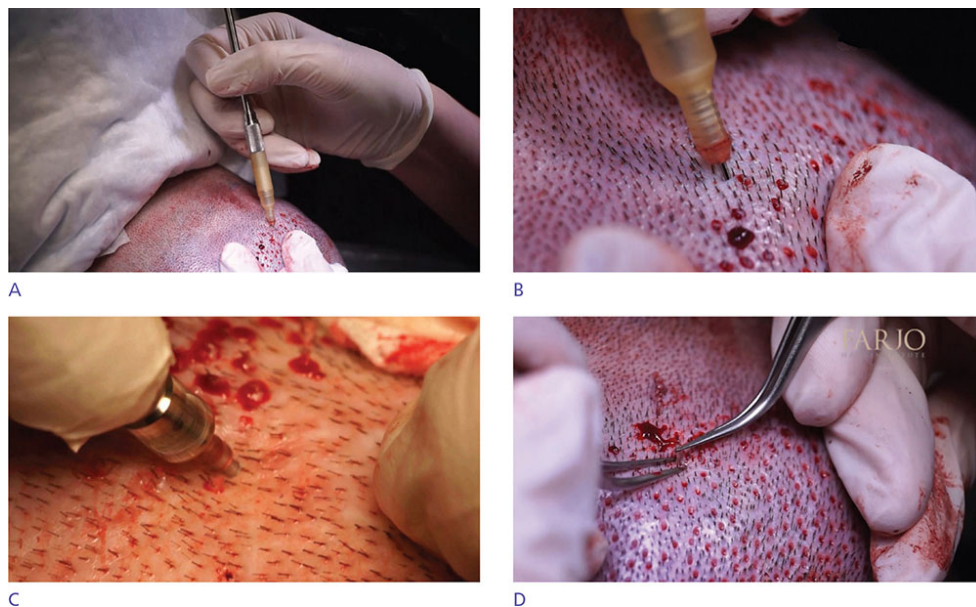


Figure 62-14. (A) FUE technique with Cole manual handle with sharp punch. (B) Skin engagement with the sharp punch. (C) Motorized Ertip sharp system. (D) Two-forceps technique for graft removal after punch incision.

With blunt or dull punches, the goal is for deeper dissection and less force on graft removal and less graft transection. The blunt dissection punch is placed central to the emerging hairs but with a depth that reaches 4 mm or more below the skin surface. Due to the blunt nature of the punch there may be a higher risk of graft burial inside the skin.

The powered version of the blunt punch involves centering the punch over the emerging hairs and engaging the sharp edge before pushing through the blunt part of the punch. This nonsharp edge tends to push hairs out of the way into the lumen rather than transecting across them. Examples of this technique include the SAFE system and the WAW flat punch tool.

Robot-assisted FUE

This refers to the ARTAS system assisted by physician oversight. A tensioner device stabilizing the skin is placed on the target harvesting area. This also has peripheral markings providing data to the camera system in the robot head for calculating the angles, orientation, and direction of the hair units as they exit the scalp. Although fully automated, the physician can manually override most processes. ARTAS utilizes the blunt punch dissecting principle (Fig. 62-15).

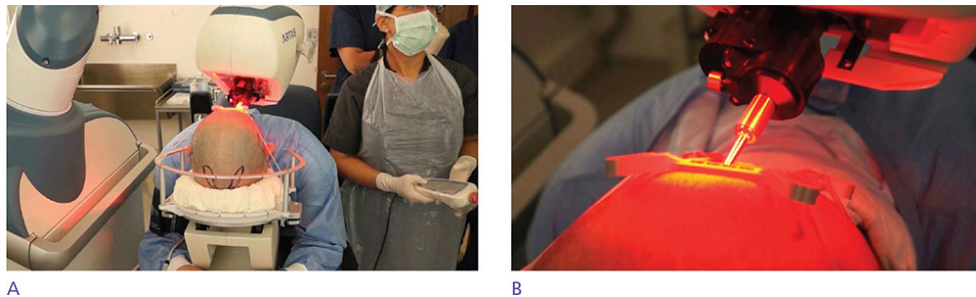


Figure 62-15. (A) ARTAS system for robot-assisted FUE by Restoration Robotics, Inc, CA. (B) Close-up of ARTAS harvesting.

Combining strip FUT and FUE can be considered to maximize the number of grafts obtained from a single procedure. The strip component can be done first and the grafts planted, followed by the FUE procedure avoiding harvesting inferior to the strip site due to risk of circulatory compromise. Generally this approach may increase the single surgery yield by up to 50%.

GRAFT PREPARATION

In FUE, there is very little graft preparation, and they can normally be returned to the scalp in the state they have been harvested. Usually, a technician examines the grafts microscopically for any loose tissue, and classifies them according to number of hairs, as well their state of transection.

In strip FUT, however, there is significant work to be done after harvesting. First, the strip is divided into slivers in a manner similar to slicing a loaf of bread. This is done carefully under the microscope to produce slivers one follicular unit wide (Fig. 62-16). The slivers are then handed to another technician who, again microscopically, separates them into the individual follicular unit group (Fig. 62-17).

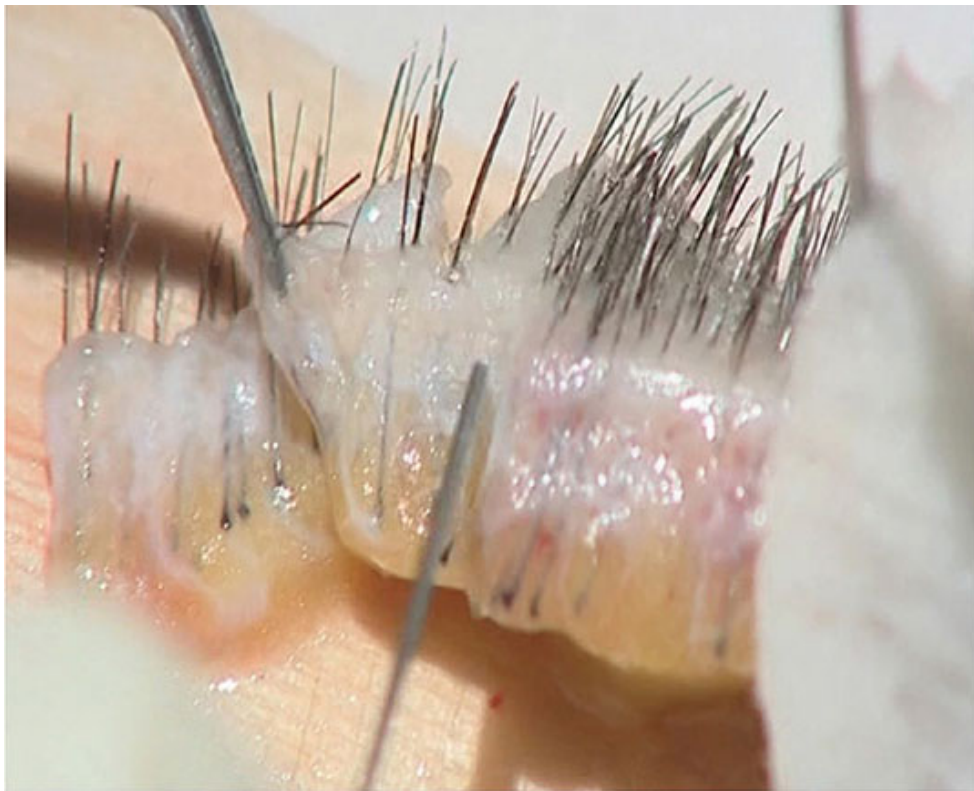


Figure 62-16. Slivering of the strip.

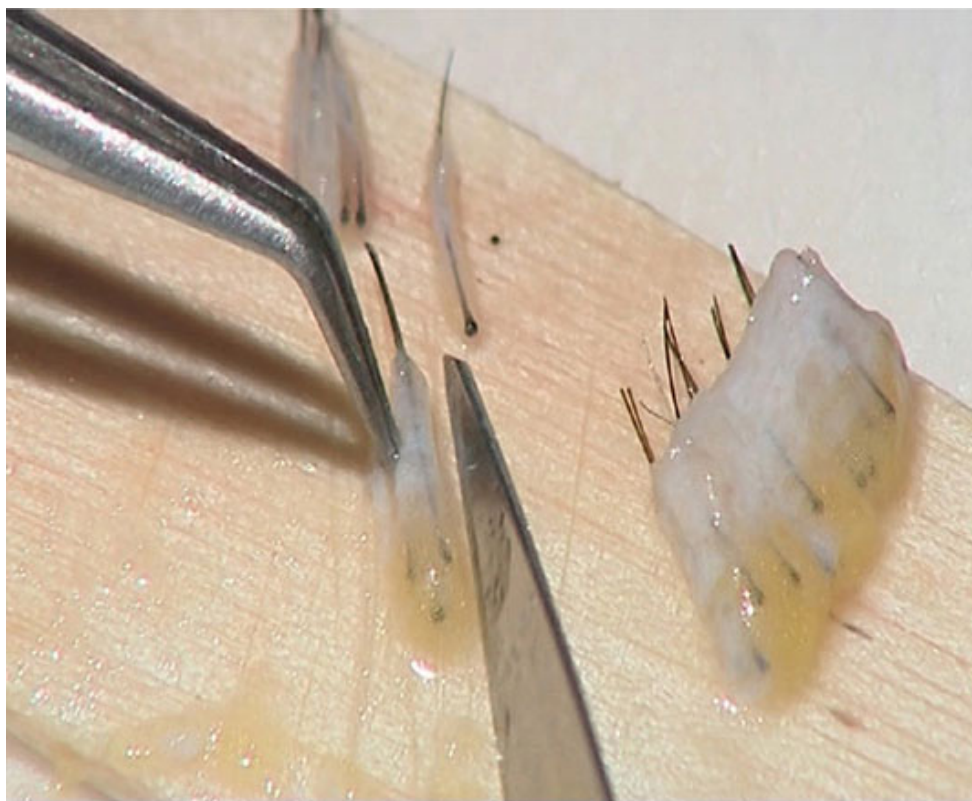


Figure 62-17. Dissecting out the follicular units from each sliver.

It is imperative that grafts are placed in an appropriate storage solution as they await placement back into the scalp. They are very susceptible to trauma and desiccation, and this is probably one of the most common contributors to disappointing growth with inexperienced operators. Ideally, grafts should be reinserted into the recipient area within 4 to 5 hours of removal from the donor area, although the sooner the better. They should be kept in a chilled holding solution while awaiting implantation. The optimal properties of different holding solutions are the subject of ongoing research. There is anecdotal evidence that bioadjuvants such as adenosine triphosphate (ATP) are of additional benefit when added to basic isotonic solutions such as Ringer's lactate. The same can be said of more advanced holding solutions such as HypoThermasol[®]. These are a reasonable choice if the grafts are kept outside the body for longer than 4 to 5 hours, or for FUE grafts which can have less surrounding protective tissue.

RECIPIENT SITE

While much time is spent by patients and surgeons debating the merits of different donor harvesting techniques, it is the skill and artistry involved in the incision site creation and graft placement that ultimately determines the aesthetic appearance of a hair transplant. The success of a hair transplant is also dependent on the handling and care of the grafts after they have been harvested and during implantation.

Recipient site incisions

Although there are very limited formal hair transplant surgery training programs available worldwide, there are several key principles involved in making incisions that should be mastered using cadaveric or synthetic training models available at workshops. These include correct and appropriate determination of incision size, depth, angle, direction, density, and geometry ([Table 62-5](#)).

Table 62-5. Variables to Consider When Making Recipient Site Incisions

-
- Size
 - Depth
 - Angle
 - Direction
 - Density
 - Geometry
-

When designing a hair transplant recipient zone, all of the incisions can be made first and the hairs implanted subsequently with forceps or implanters. This allows a degree of flexibility if more or less grafts are harvested than anticipated, but runs the risk of some sites being missed when implanting grafts. Alternatively, a “stick and place” technique can be used with either implanters as a “one-step” method, or incisions can be made and immediately filled with grafts using forceps or implanters. This ensures that no incisions remain unfilled but requires significant design skill so that the entire recipient area is sufficiently filled with available grafts.

Size

The width of an incision to implant a follicular unit graft will be influenced not only by the dimensions and shape of the instrument used, but also the quality of the recipient site skin and angle of instrument insertion. There are many different tools used to make incisions, though there is no consensus on which is the best (Fig. 62-18). Various-sized hypodermic needles, needle-tipped implanter devices, blades fitted onto needle holders, or custom made handles may be considered (Figs. 62-19 and 62-20). What can be agreed upon is that if grafts are going to be implanted after the incisions are made, the incision should be large enough to insert the graft with minimal manipulation but small enough that the graft fits snugly, does not pop out, and tamponades any bleeding. Several incisions should be tested for different follicular unit sizes initially to ensure the correct size sites are made prior to making all the incisions.



Figure 62-18. Variety of needles and blades for recipient site making.

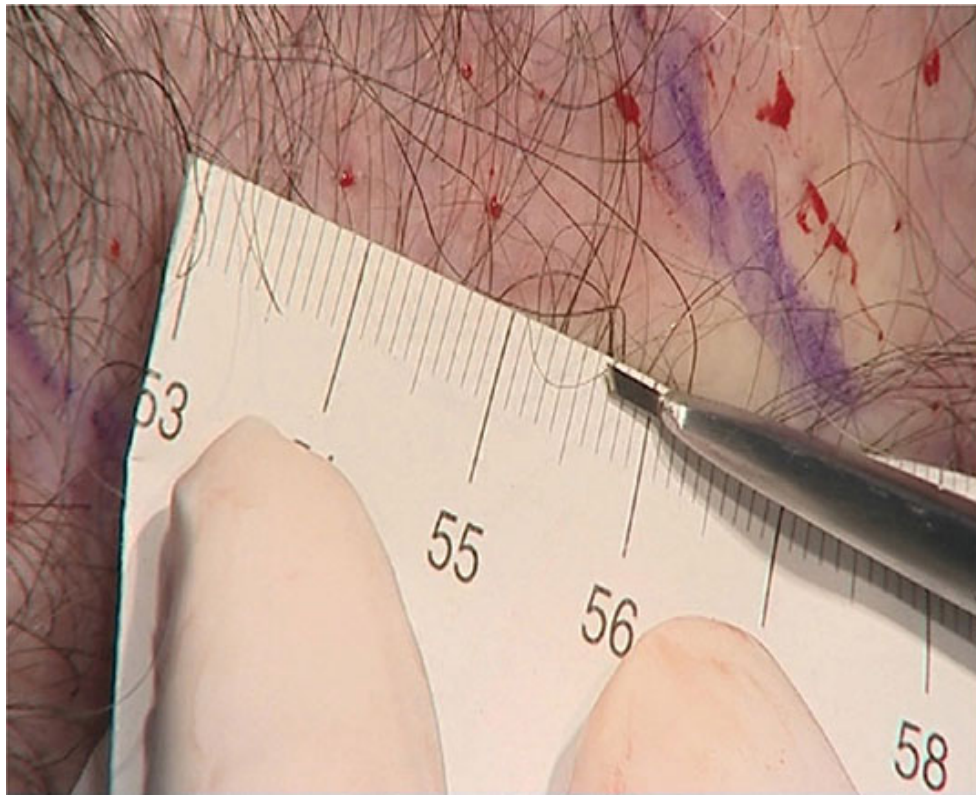


Figure 62-19. Cut-to-size blade attached to needle holder for depth control.



Figure 62-20. Implanter example by Lion.

Depth

In addition to testing the width of the incisions, the depth should also be decided on a case-by-case basis and will be dependent not only on the length of an individual's follicle, but also on the recipient site skin and subcutaneous tissue qualities. This can vary considerably not only from patient to patient, but also in different areas of the scalp.

Angle

The appropriate angle of the incision depends on the location within the scalp where the hairs are being implanted, but should also follow the angle of exit of any existing hairs to avoid damaging roots and the subcutaneous portion of the hair shafts adjacent to incisions. Angles will vary from a forward 45 degrees in the hairline of most individuals to an upright 90 degrees in the crown, then reversing to a very acute angle if simulating the downward hair growth direction in the occipital region ([Fig. 62-21](#)). Incision angle is perhaps most critical when performing eyebrow transplants, where the angle should be as acute as possible so that the hairs grow almost horizontally.



Figure 62-21. Acute angulation of recipient-site–making blade.

Direction

The direction of the incision will determine the direction of hair growth and the overall flow of the hair (Fig. 62-22). This can be designed de novo by the surgeon if there is no existing hair in bald areas, but should follow the direction of any existing hair. Correct design of hair direction is crucial in the design of whorls in the crown, even more so if there are two or even three naturally occurring whorls that need to be replicated.



Figure 62-22. Recipient site design, direction, and distribution in the hairline and frontal forelock.

Density

The number of incisions made per square centimeter will determine the density of hair growth. Smaller incision-making devices allow greater density, varying between 25 and 40 incisions/cm². Patients should be counseled on the visual density that will be achieved, which is influenced by hairs per graft as well as hair caliber, color, texture, and curl.

Geometry

The orientation of the incisions can have an impact on the appearance of transplanted hair. The terms “sagittal” and “coronal” are used to describe the orientation of incisions, though these terms are used in relation to the intended direction of hair growth (whether de novo or in relation to existing hair growth direction) rather than in relation to anatomical directions. Thus, sagittal refers to a direction that is parallel to the hair follicle, whereas coronal means perpendicular to the direction of the hair shaft. A three-hair follicular unit placed in an anatomically sagittal direction will look like a single hair when viewed from the front, whereas a three-hair follicular unit

placed in an anatomically coronal incision will look like three hairs side by side when viewed from the front. Using sagittal and coronal incisions for different size grafts can also aid in differentiating which incisions are for which grafts (Fig. 62-23). Likewise, the creation of incisions, either sagittally or coronally oriented, in linear rows will give an artificial appearance to hair growth, whereas triangulation of the incisions will result in a more natural appearance (Fig. 62-24).



Figure 62-23. The lower incisions are sagittal (parallel), whereas the upper ones are coronal (perpendicular to the hair direction).

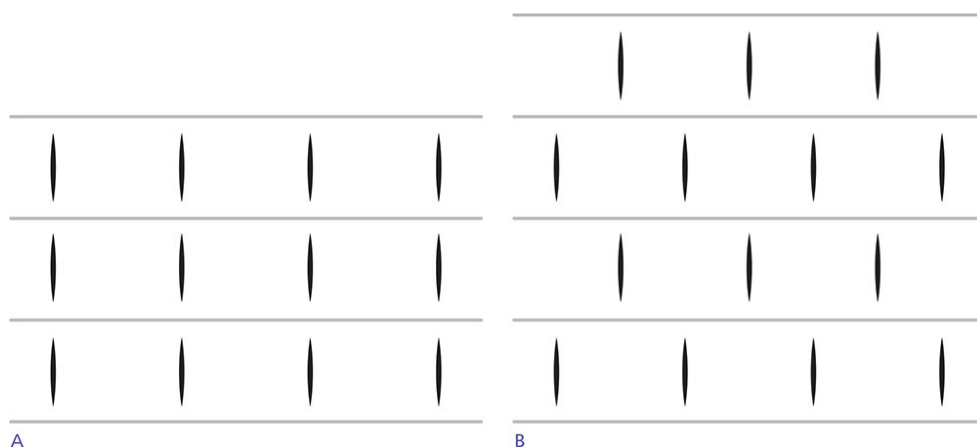


Figure 62-24. (A) Sites aligned in lines or squares give an unnatural regimented appearance. (B) An alternating or triangular pattern gives a more irregular and natural appearance.

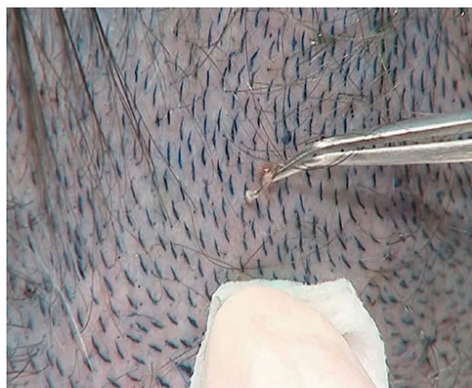
Hairline design merits precise attention to detail as it will come under the closest scrutiny from the patient and be most visible to observers. An irregularly irregular pattern or “snail’s trail” design is now accepted as the gold standard, with single hairs placed randomly in front of the hairline to simulate the rogue hairs seen in a natural hairline (Fig. 62-22).

Implanting

Follicular unit grafts should always be handled as gently as possible, both during dissection and implantation. In particular, the bulb area should not be crushed, and this is one of the arguments for using implanters that minimize the handling of the grafts and manipulation during insertion. Forceps are commonly used, but require the grafts to be held by the tissue surrounding the bulb (Fig. 62-25). This is more easily done with strip FUT grafts, which tend to be chubbier than FUE grafts that may have minimal, if any, tissue surrounding the bulbs of the hairs. When using implanters, grafts can be loaded without touching the bulb at all, thereby avoiding any mechanical crushing forces to the bulb. However, when grafts are inserted into the skin using the implanter plunger, the bulb can still be damaged if excess force is used.



A



C



B

Figure 62-25. (A) Examples of placing forceps. (B) Typical setup of operators placing grafts on a patient. (C) Jewellers placing forceps action.

POSTOPERATIVE CARE

The patient can wash the donor site the next day, and normal washing of the grafted area can resume after 1 week. Most surgeons recommend frequent misting of the recipient area with a saline-based solution over the first few days. Strenuous exercise should be avoided over the first postoperative week.

Most hair transplant surgeons do not use bandages, though Vaseline gauze can be used for the first day in FUE cases where there may be some oozing from the donor site.

From 7 to 10 days postoperatively, the majority of grafts will start to shed their surface crust and probably the external hair shaft as well. New hairs will start to grow after 3 to 4 months, but will not reach maturity demonstrating the final result until 8 to 14 months from the date of the procedure ([Table 62-6](#)).

Table 62-6. Common Postoperative Complaints

Pain
Edema
Bleeding
Crusting
Graft dislodgement
Anagen or telogen effluvium
Pruritus
Hypoesthesia

Postoperative edema may occur, but prevention is possible using ice packs from the day after surgery as well as sleeping with the head elevated at 45 degrees for 3 days. A headband may be used to prevent fluid moving down the forehead.

Anagen and/or telogen effluvium can both occur after surgery when transplanting into thinning, rather than bald, areas. This is especially common in female patients who should be warned that this may occur and encouraged to use minoxidil before and from 1 week after surgery.

COMPLICATIONS

Complications fall into two categories: aesthetic and medical/surgical. Aesthetic complications are probably more common, especially for the inexperienced surgeon. These include patient expectations not being met when the surgeon and patient have not understood each other's expectations from the surgery. This may also be due to choosing the wrong patient, for example, a young patient with rapidly progressing hair loss that has not first been stabilized with medications. Poor design may be an issue, including wrong angle of placement of grafts or grafts placed incorrectly along the hairline.

Occasionally a patient will be present with poor growth, which could be due to an underlying skin condition (e.g., scarring alopecia such as lichen planopilaris) that was not diagnosed, postoperative infection, poor graft handling, or storage issues during the procedure. Sometimes no cause is found.

Medical/surgical complications include pain, bleeding, edema, sensory loss (temporary or permanent), and folliculitis. Less commonly, wound dehiscence, donor or recipient area necrosis, and widened, keloid, or hypertrophic scarring can occur.

CONCLUSIONS

The natural appearance of a hair transplant is dependent on the ability of the surgeon to create appropriate incision sites, taking into account the variables that affect graft placement. The survival and subsequent growth of transplanted follicular unit grafts are dependent on the storage and handling of the grafts by the entire hair transplant team. It is equally important to leave the donor area with the best possible aesthetic appearance that will stand the test of time by respecting the safe donor area and producing scars from either

strip FUT or FUE that will both be hidden and not create styling issues for the patient.

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CHAPTER 63 Lasers for Burns and Trauma

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SUMMARY

- The prevalence of hypertrophic scarring, much of it trauma-related, in the developed and developing world is currently at an all-time high.

- Given the ubiquity of hypertrophic scarring and its potential impact on health-related quality of life, it is paramount that patients have access to safe and effective treatment.

Beginner Pearls



- The current literature suggests that 32% to 72% of burn patients will go on to develop hypertrophic scarring.
- The physical impact of hypertrophic scarring varies widely and should not be assessed through visual inspection alone.
- The pulsed dye laser (PDL) has proven to be a cornerstone in the treatment of erythematous hypertrophic scars.

Expert Pearls



- Ablative fractional laser (AFL) is primarily used for hypertrophic scars.
- When using IPL, the 515- to 590-nm filters are commonly used with a pulse width of approximately 10 ms.
- Often, the simplest approach is best, including Z- or W-plasty in conjunction with AFL, PDL, and other adjunctive therapies.

Don't Forget!



- In general, NAFLs do not have a significant role in the management of hypertrophic scars at this time.
- The use of combination intralesional corticosteroid/5-FU therapy has been associated with improved scar regression, reduced recurrence, and fewer side effects.
- Z-plasty performed within scars is virtually undetectable, and the resulting decrease in tension helps scar maturation.

Pitfalls and Cautions



- To avoid unwanted atrophy, the concentration of triamcinolone is subsequently reduced as scars flatten.
- A protocol that promotes the safety and well-being of the laser surgeon and the patient should be established in every practice.

Patient Education Points



- Given the complexity of hypertrophic scar management and the general lack of awareness of the available treatment options and associated outcomes by the patient, it is essential to incorporate this discussion during the clinical evaluation.
- The understanding of the patient's needs and expectations by the physician produces greater satisfaction of care, which has been correlated with greater adherence to therapy, less doctor shopping, and a lower propensity to sue for malpractice.

CHAPTER 63 Lasers for Burns and Trauma

INTRODUCTION

The prevalence of hypertrophic scarring in the developed and developing world is currently at an all-time high. Modern advances in acute burn and trauma care have led to unprecedented survival rates, particularly in the most severely injured patients. As these patients transition from acute to chronic care, they are confronted with the long-term sequelae of hypertrophic scarring. Given the ubiquity of hypertrophic scarring and its potential impact on health-related quality of life, it is paramount that patients have access to safe and effective treatment. While the focus is on hypertrophic scarring, many of these techniques can be extended to keloid scars, recognizing that keloids often require more aggressive management and additional adjunctive therapies.^{1,2}

BACKGROUND

Societal disease burden

Hypertrophic scarring secondary to trauma, burns, and surgical interventions is a major source of morbidity worldwide and is often mechanically, aesthetically, and symptomatically debilitating. Advances in acute care trauma and burn protocols have resulted in increased patient survival rates to over 95% in these populations.³ Patients with wounds that have historically proved fatal are now surviving and facing the long-term sequelae of their injuries, including hypertrophic scarring.

Although the exact etiology is poorly understood, hypertrophic scarring is widely considered a dysfunction in the normal process of wound healing leading to abnormal fibroproliferation within the dermis.⁴ In many cases, the impact on patient quality of life is severe, and is often underrecognized. Anatomic deformity is both physically disabling and socially stigmatizing, leading to impairments in psychosocial functioning (Figs. 63-1 and 63-2). Annually in the United States, 8.5 million patients present to the emergency department with injuries at risk for hypertrophic scarring with a range of diagnoses including open wounds (6.3 million), superficial injuries, and burns (0.5 million).⁵

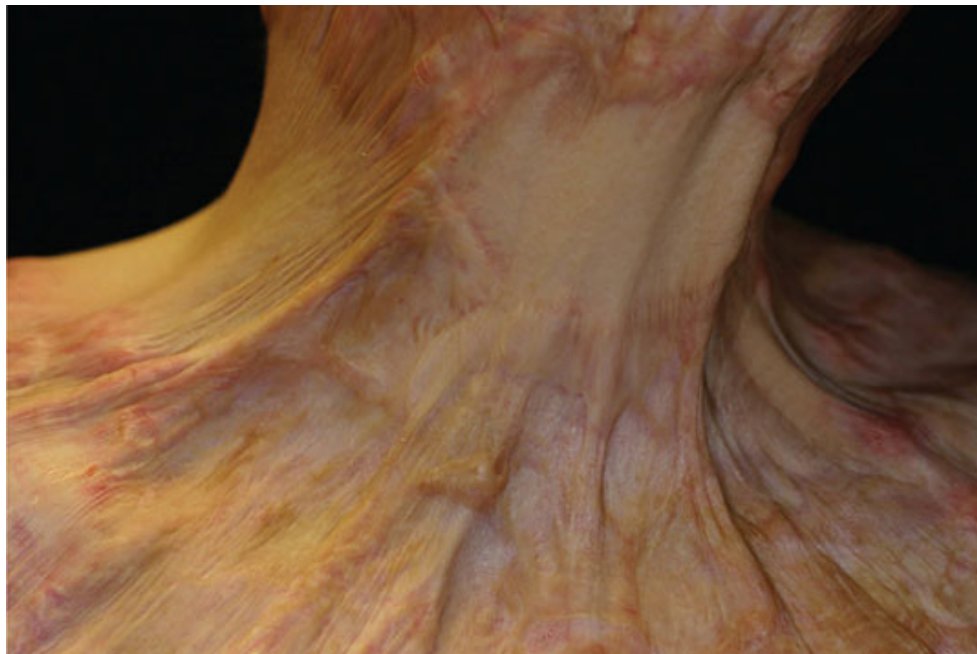


Figure 63-1. Burn scar contractures accentuated upon neck extension. Contractures limit range of motion and negatively impact social interactions.



Figure 63-2. Burn scar contractures of the hand impairing grip function and hindering activities of daily living.

The current literature suggests that 32% to 72% of burn patients will go on to develop hypertrophic scarring.⁶ Although the rate of hypertrophic scar formation may be lower in the trauma population, physicians providing care for these patients can attest that hypertrophic scarring is a common and challenging clinical problem. Iatrogenic scarring, however, is unequivocally the most common cause of hypertrophic scar formation, with over 48 million surgical inpatient procedures performed in the United States annually.⁷ The

techniques and approaches discussed below may also be generalized to the iatrogenic scar population.

Patient impact

Hypertrophic scarring may result in both physical and psychosocial impairments, which severely impact health-related quality of life. In the burn population, 13% to 23% of patients suffer from depression and 13% to 45% suffer from posttraumatic stress disorder (PTSD) related to both their mechanism of injury and resultant scarring.⁸ In orthopedic trauma patients, the prevalence of depression has been reported as high as 45%, which correlates directly with global disability.⁹

The physical impact of hypertrophic scarring varies widely and should not be assessed with visual inspection alone. Relatively minor scars can often be as symptomatic as larger scars. A thorough history and physical examination is required to characterize the impact better. In addition, physical symptoms may evolve as the site of injury transitions from wound to immature scar and finally to the final mature scar. Patients often experience varying degrees of pruritus, burning, numbness, and dysesthesia at the affected site, although some patients are noted to be completely asymptomatic.^{10–12} Severe deformity may impair the mechanical characteristics of the skin and, in turn, functionality. Mechanical deformation characteristics of scars include increased dermal thickness, decreased elasticity/extensibility, and scar contracture. Observed decrements in the range of motion result in adaptive shortening of the underlying musculotendinous units and further restrictions in functional mobility. These impairments are directly correlated with long-term disability and adverse impact on the quality of life.^{13–17} Aesthetically, hypertrophic scars often have variations in erythema, pigmentation, and texture. The combination of functional impairment, physical symptoms, and aesthetic disfigurement leads to long-term psychosocial effects and severely impacts health-related quality of life in this patient population.⁸

An additional consideration is the potential loss of adnexal structures such as sweat glands and pilosebaceous units. Loss of thermoregulatory function secondary to hypohidrosis or anhidrosis has the potential for added morbidity and a negative impact on health-related quality of life.^{18,19} The

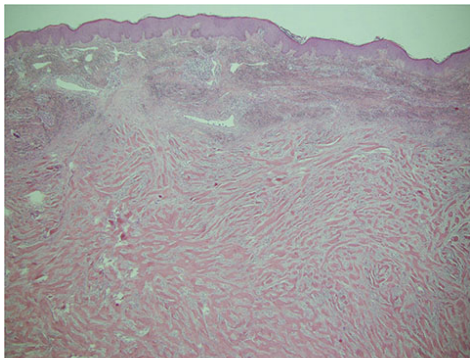
loss of the pilosebaceous unit results in significant deformity, particularly on the scalp and face. Though scars can be treated as outlined below, the ability to regrow hair is not yet available. Hair transplantation may be used to recreate eyebrows or other facial hair lost secondary to scar formation.

Pathophysiology of scars

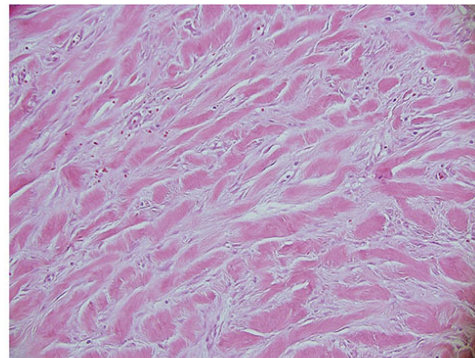
Hypertrophic scarring represents a form of exuberant wound healing; the other is keloid scarring (keloids). The two must be carefully distinguished, as keloids tend to be recalcitrant to treatment and demonstrate a higher risk of recurrence.²⁰ While both keloids and hypertrophic scars are raised, hypertrophic scars are confined to the boundaries of the initial injury. Keloids do not share this limitation, and can be quite prolific, extending beyond the site of original trauma.²¹ Keloids are less likely to mature with time and have been shown to have specific genetic associations. However, both hypertrophic and keloid scarring are more prevalent in Asian, African, and Hispanic populations (Fig. 63-3).²² The underlying etiology of both conditions is thought to represent a disequilibrium between collagen production and degradation associated with abnormal fibroblast proliferation.^{23,24} Keloids are histologically characterized by thickened, hyalinized bundles of collagen arranged in a haphazard array, with decreased vascularity, increased mast cells, and an increased absolute count of fibroblasts (Fig. 63-4A and B).²⁵ Hypertrophic scarring also demonstrates an increased number of fibroblasts and mast cells but has collagen bundles oriented in a lamellar pattern parallel to the skin surface, with increased vascularity (Fig. 63-5A and B).²⁵ These features may vary significantly with scar maturity.



Figure 63-3. Keloid scar of the chest secondary to shrapnel wound. Extensive scarring greatly exceeded initial injury 5 mm in size.



A



B

Figure 63-4. Keloid scar histology: hematoxylin and eosin (H&E) stain. (A) 40× magnification demonstrating thickened, hyalinized bundles of collagen arranged in a haphazard array. (B) 200× magnification demonstrating decreased vascularity, increased presence of mast cells, and prominent fibroblasts. (Used with permission from Wendi Wohltmann, MD; San Antonio Military Health System).

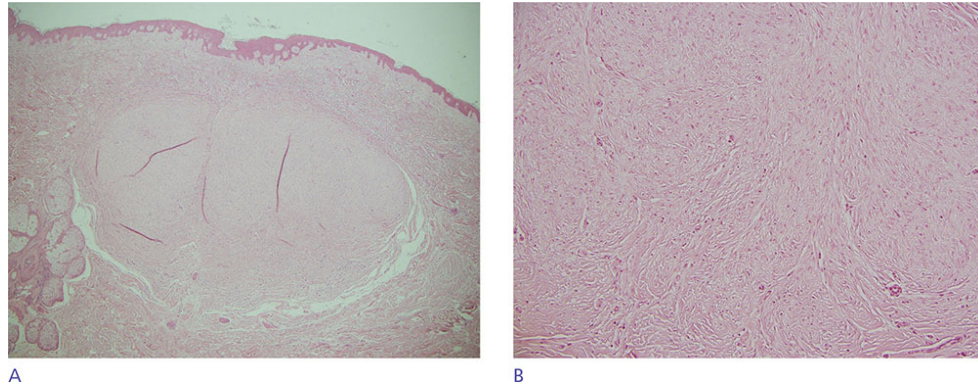


Figure 63-5. Hypertrophic scar histology: H&E stain. (A) 40× magnification demonstrating prominent collagen bundles oriented in a lamellar pattern parallel to the skin surface. (B) 200× magnification demonstrating increased vascularity, increased mast cells, and increased fibroblasts. (Used with permission from Wendi Wohltmann, MD; San Antonio Military Health System).

Evaluating and understanding the pathophysiology of hypertrophic scar formation continues to pose a challenge to investigators. In general, a failure in the wound-healing process impedes the transition from the initial proliferative phase through the remodeling phase and subsequently through the maturation stage leading to deficits in function and appearance of the scar.⁴ Fibroblast proliferation and excessive secretion of growth factors such as vascular endothelial growth factor, connective-tissue growth factor, and transforming growth factor-beta (TGF- β) have long been associated with hypertrophic scar development. However, the exerted effect of these growth factors and the associated cytokine milieu is just now beginning to be understood.^{26–31}

Prior to the third trimester, a human fetus is able to heal wounds without scarring.³² Decreased fibroblast activity and inflammatory response have been observed in this cohort, although the relationship between these findings and scarless wound healing is unclear.³¹ There appears to be a complex interplay of cell signaling akin to quorum sensing between the local wound and physical environment, in part influenced by cytokines, local wound tension, and oxygen saturation.^{33–36}

Wound tension is frequently associated with hypertrophic scarring. Fibroblasts, specifically myofibroblasts, demonstrate mechanoresponsiveness and are reported to play a key role in hypertrophic scarring and scar contracture. In vitro studies suggest that wound tension upregulates matrix remodeling genes and downregulates normal cellular

apoptosis. In a process known as mechanotransduction, intracellular pathways convert mechanical cues into biochemical responses via complex mechanoresponsive elements that often blur the distinction between physical and chemical signaling.³⁷ The result is an increased population of fibroblasts, each of which produces more matrix material. This “double burden” may partially explain the pathophysiology of hypertrophic scars.³⁸ Not surprisingly, decreasing tension during the wound-healing process results in a reduction in subsequent hypertrophic scar formation in both large animals and in human phase 1 studies.³⁹

Evidence-based approaches

State of the research

As with most diseases in medicine, hypertrophic scarring exists on a spectrum of clinical severity. The majority of hypertrophic scarring presenting to the dermatologic surgeon will be appropriate for management in the office, under topical or local anesthesia using a multimodal approach to include traditional surgical intervention, laser surgery, and pharmacotherapy. It is critically important to recognize and refer those patients that require additional resources and techniques such as extensive scar excision or grafting, hair transplant, physical therapy, occupational therapy, and use of general anesthesia. In these advanced cases, a coordinated, team-based approach is critical to patient outcome.

Physicians have reported clinical improvement in hypertrophic scars treated with laser surgery for nearly 20 years. During that time, there have been many case reports, case series, retrospective reviews, and small, prospective trials evaluating the efficacy of various laser platforms. In 2011, a systematic literature review was conducted regarding the role of laser surgery for hypertrophic scarring, which noted the lack of studies that met quality trial criteria.⁴⁰ Despite continued advances over the past several years, there still exists a need for well-designed studies that minimize industry bias, use and/or establish new well-defined scar characteristics, validate outcome measures, standardize measurement methods for all aspects of the scar and function, use follow-up periods of at least 6 months, and publish well-defined laser settings.⁴⁰ Below, we will review the current

literature to include evidence-based indications for the utilization of laser surgery in hypertrophic scarring.

Hypertrophic scar prevention

With the exception of iatrogenic scarring from cutaneous surgery, it is uncommon for the typical dermatologic surgeon to be involved in the acute management of burn and trauma wounds that result in hypertrophic scarring. A general understanding of the initial therapeutic options in these patient populations better facilitates informed collaboration with our colleagues and gives the dermatologic surgeon awareness of the tools needed to manage postsurgical patients with a high risk of hypertrophic and keloid scarring.

Over 200 years have passed since Benjamin Franklin's death, but his adage that "an ounce of prevention is worth a pound of cure" still rings true, particularly in the management of hypertrophic scarring. Once the wound epithelium is sufficiently stable, there are a number of techniques utilized to minimize the risk of hypertrophic and keloid scarring. In the burn population, many surgeons utilize pressure garment therapy (PGT) as a preventative and treatment modality for hypertrophic scars. Depending upon total body surface area affected, patients wear bandages or garments that exert 15 to 40 mmHg of positive pressure for approximately 6 months.⁴¹ While a recent meta-analysis of PGT did not show a definitive positive effect, PGT is a popular and generally accepted modality, and the dermatologic surgeon should be familiar with this technique.⁴¹

Silicone gel and sheeting represent additional conventional techniques for hypertrophic scar prevention. Silicone gel or sheets are applied to the affected areas daily and remain in place for 12 to 24 hours for 3 to 6 months.³⁶ Although studies evaluating the efficacy of silicone gel and sheeting have been noted to be of poor quality, a 2013 Cochrane Database Systematic review showed a reduction in risk of patients treated with silicone gel sheeting when compared to no treatment (risk ratio [RR] 0.46, 95% CI, 0.21–0.98).⁴²

Numerous adjuvant therapies have also been evaluated for their role in acute phase management, including laser surgery, radiation therapy, cryotherapy, and pharmacotherapy with agents such as 5-fluorouracil (5-FU), bleomycin, onion extract gel, corticosteroids, antihistamines, and

analgesics.^{42–48} While these techniques are promising, additional studies must be conducted to better characterize the benefit to this patient population.

Hypertrophic scar management

Every scar has a story, both to the patient and to the clinician. The treatment approach for hypertrophic scars depends greatly upon that clinical story, in particular the scar maturity, associated symptoms, impairment of function, and aesthetic disfigurement. In the acute phase, the goal of treatment is effective expedition of maturation and optimization of the scar environment. Once mature, methods must be employed that facilitate remodeling and normalization of wound healing. Ultimately, the aim is to return every scar to its uninjured state.

In order to optimize the treatment of hypertrophic scars, it is paramount that the dermatologic surgeon be capable of employing laser surgery, surgical interventions, and pharmacotherapy, often at the same visit.

Selective photothermolysis of the vasculature

Pulsed-dye laser

Through the induction of controlled damage to the dermal microvasculature, the nonablative pulsed-dye laser (PDL) has proven to be a cornerstone in the treatment of erythematous hypertrophic scars since its introduction.⁴⁹ With its selective chromophore target of oxyhemoglobin, the PDL is considered the gold standard treatment for cutaneous vascular lesions such as port wine stains and other capillary malformations. Damage to microvasculature in the neovascularized scar tissue generates a hypoxic environment leading to (1) collagen fiber heating, realignment, and decreased type III collagen deposition, (2) decreased fibroblast proliferation, and (3) histamine release, influencing fibroblast activity.^{49–53}

The PDL produces pulses of light at the optimal wavelengths of 585 nm or 595 nm with pulse durations ranging between 0.45 and 40 ms. A pulse duration between 0.45 and 1.5 ms is optimal for the reduction of erythema in hypertrophic scars. The main clinical outcomes of scar treatment with PDL are decreased erythema and pruritus.³⁶ Improvement in scar volume, pliability, and skin elasticity has also been reported, with a proposed

mechanism of upregulation of matrix metalloproteinase expression.^{40,54} The nonablative and minimally invasive nature of the PDL yields little to no postprocedural downtime and a minimal risk of adverse sequelae.

The most common postprocedural effects include transient edema, ecchymosis, hypopigmentation, and/or hyperpigmentation of the treatment area. To minimize postprocedural hyperpigmentation, sun avoidance should be prescribed for at least 72 hours. Treatment intervals for PDL should be between 6 and 8 weeks, although in some cases a low fluence, short pulse width treatment every 2 to 3 weeks can be considered. PDL therapy is less effective on thicker (>1.0 cm) hypertrophic scars, particularly if tension is present.^{40,54} Tension-relieving Z-plasty surgeries and/or small, inconspicuously placed grafts are a powerfully synergistic adjunct in such cases and may eliminate the need for extensive scar excision.⁵⁵ Scar revision techniques will be discussed below.

Frequency-doubled potassium titanyl phosphate, neodymium-doped yttrium aluminum garnet laser

The 532-nm potassium titanyl phosphate, neodymium-doped yttrium aluminum garnet laser (KTP) offers an additional option for preferential destruction of dermal vasculature in scars. Although commonly referred to as a KTP laser, the platform is a 1,064-nm neodymium-doped, yttrium aluminum garnet (Nd: YAG) laser that utilizes a KTP crystal as a frequency-doubling device to generate the desired 532-nm wavelength. KTP has been shown to have comparable efficacy in erythema reduction of surgical scars when compared to the 595-nm PDL.⁵⁶ Traditionally, the 1,064-nm Nd:YAG laser, without frequency doubling, has been utilized to treat vascular lesions. However, the therapeutic window is very narrow when compared to other vascular lasers resulting in statistically significant increases in postprocedural erythema, hyperpigmentation, edema, pain, and scar formation.⁵⁷

Intense pulsed light

An alternative treatment option for erythema and hyperpigmentation reduction in hypertrophic scars is intense pulsed light (IPL). IPL emits a broad band of pulsed light in the 515- to 1,200-nm spectrum that can be selectively filtered to target pigmentation and microvasculature within the dermis to reduce

erythema and nonspecific hyperpigmentation in hypertrophic scars.⁵⁸ Specific settings for IPL devices are difficult to recommend due to the plethora of devices available, the wide spectrum of selective filters, and the lack of consistent descriptions in the literature. Currently, evidence of the efficacy of IPL in the treatment of hypertrophic scars is scant, and further studies are warranted. IPL does prove particularly useful when improvement of scar erythema reaches a plateau with the PDL or in cases with concomitant postinflammatory hyperpigmentation. However, a slow and conservative approach is vital, as the therapeutic window is narrow and bulk heating and overtreatment may lead to ulceration and worsening of the scar. The 515- to 590-nm filters are commonly used with a pulse width of approximately 10 ms. Appropriate use of local skin cooling is critical, as blistering and ulceration can be seen. Some scars, including those associated with split-thickness skin grafts, demonstrate large variations in skin thickness creating an uneven topography that makes it difficult to achieve uniform contact cooling (Fig. 63-6). Uneven cooling leads to “hot spots” where complications are far more likely to occur.



Figure 63-6. (A) Split-thickness skin graft scarring of the left upper extremity with focal hypertrophic scars and islands of unaffected skin. (B) Split-thickness skin graft scarring extending across multiple joints limiting range of motion of the wrist and hand.

Fractional photothermolysis

Introduction

Fractional photothermolysis was initially developed as a less aggressive alternative to the fully ablative resurfacing procedures popularized in cosmetic laser surgery.⁵⁹ Prior to the development of fractional photothermolysis in 2004, ablative laser resurfacing utilization had significantly waned secondary to associated risks of prolonged erythema, milia formation, delayed wound healing, viral and bacterial infections, and delayed hypopigmentation.⁶⁰

Fractional photothermolysis avoids these pitfalls by treating a predetermined portion of the hypertrophic scar. Fractional lasers create a pixelated pattern of thermal injury throughout the epidermis and dermis of the treatment area. The columns of ablation and/or thermal injury are referred to as microscopic treatment zones (MTZs) and range from a few to several hundred micrometers (microns) in diameter and may reach up to 4 mm in depth.⁵⁹ The diameter of the MTZs is determined by the wavelength, optics, and pulse width of the laser. The depth of penetration is directly proportional to the fluence selected and pulse profile. The physician is able to adjust the density of the MTZs per square centimeter, depending on their goals for treatment (Fig. 63-7A, B, C). The intervening untreated skin acts as a reservoir of epidermal and hair follicle stem cells, allowing short keratinocyte migration and collagen regeneration from 360 degrees around each MTZ, inducing a controlled remodeling of deeper collagen and shorter healing time.⁶¹ Despite treatment of a smaller percentage of the scar, collagen remodeling and improvements in dermal architecture are diffuse throughout the target area.^{62,63}

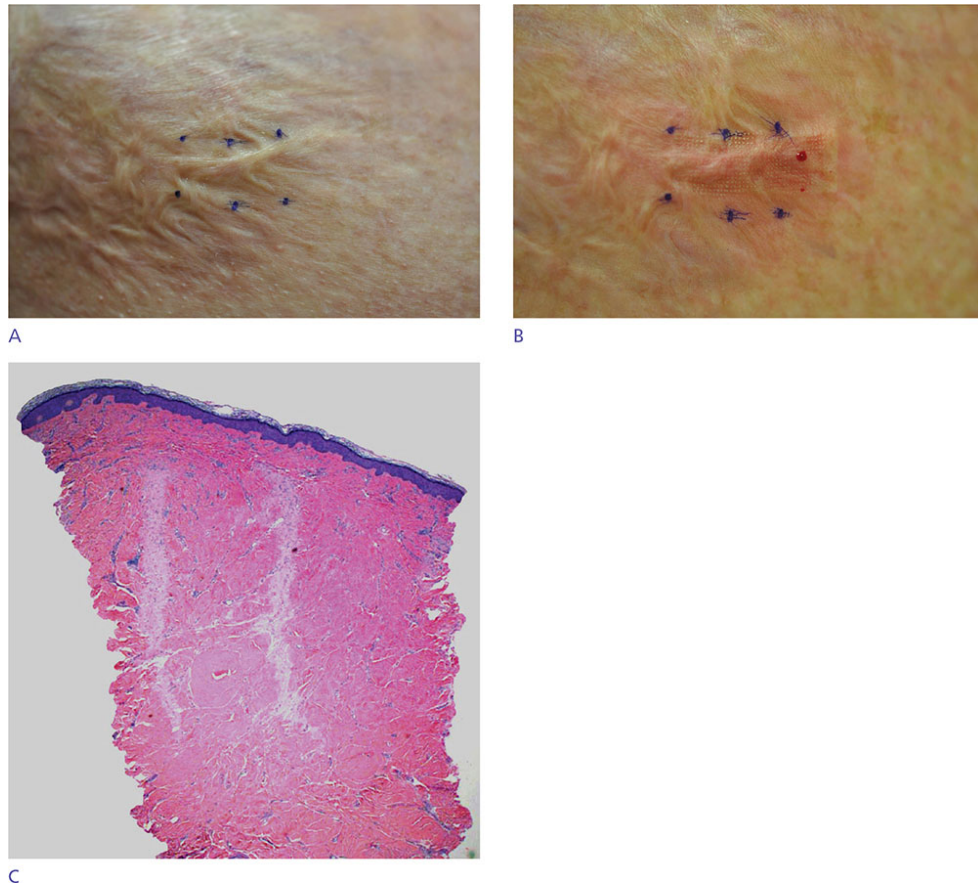


Figure 63-7. Hypertrophic scar treatment with AFL. (A) Hypertrophic scar with marked treatment area. (B) Hypertrophic scar post-treatment demonstrating pixelated pattern of thermal injury. (C) Histology of hypertrophic scar treated with AFL. Epidermal healing is complete with initiation of collagen remodeling process.

Although fractional lasers can be either ablative or nonablative, ablative fractional laser (AFL) is primarily used for hypertrophic scars. Studies evaluating the impact of fractional nonablative photothermolysis on hypertrophic scars are currently limited. In general, non-AFLs do not have a significant role in the management of hypertrophic scars at this time. The two most popular and widely available ablative fractional platforms are the 10,600-nm carbon dioxide (CO₂) and 2,940-nm erbium-doped: yttrium aluminum garnet (Er:YAG) lasers. The targeted chromophore of both lasers is intracellular water. This results in tissue vaporization and varying degrees of coagulation of the surrounding extracellular proteins. This process stimulates the molecular changes necessary to elicit the improvements observed clinically.

Molecular changes

At the molecular level, AFLs induce a number of changes that affect the scar and its microenvironment. These changes include fibroblast apoptosis, upregulation of heat shock proteins, downregulation of transforming growth factors and basic fibroblast growth factor (bFGF), and shifts in type I and III procollagen levels.⁶⁴ The upregulation of matrix metalloproteinases allows for the degradation of fibrotic collagen, clearing the way for neocollagenesis.⁶⁴ These molecular alterations are appreciated throughout the dermis, extending well beyond the areas of treatment with subsequent normalization of collagen structure and arrangement. Analysis of collagen present in scars after AFL has shown a collagen subtype profile resembling that of nonwounded skin.⁶⁵ Histologic examination has also demonstrated a significant increase in vascular density after treatment along with a paradoxical decrease in clinical erythema. This interesting relationship provides an area for future study, given the possible decrease in erythema and wound tension reduction with AFL therapy.⁶⁶

Clinical improvement

Physicians performing laser surgery for hypertrophic scars have consistently reported improvements in function, symptoms, and aesthetics of the skin after as little as one treatment of AFL.⁶³ Clinically, patients report improvement in stiffness, range of motion, pain, pruritus, pigmentation, and erythema; these have been well-documented utilizing measures of scar improvement such as the patient and observer scar assessment scale (POSAS) and the Vancouver Scar Scale (VSS).^{48,67,68} Objective quantification and correlation with the subjective measurements have yet to be well-defined.

Recently, interim data from the first prospective, controlled trial with objective measurements in hypertrophic scars before and after ablative fractional CO₂ laser therapy was presented at a national conference by the authors.⁶⁹ At the time of the interim data analysis, 18 of 24 subjects with mature, hypertrophic burn scars had fully completed the study. Traditional subjective quantification was performed in addition to a number of objective measurements including dermal thickness, elasticity, and extensibility before and after three treatments of ablative fractional CO₂ laser at 3-month intervals. A wash-in period of 3 months was utilized to establish scar stability. Previously reported improvements in subjective measurements

were replicated. For the first time, objective quantification was reported that correlated with the subjective improvements including a 22% reduction in scar thickness, 53% improvement in elastic deformation (quick stretch), a 37% increase in extensibility (total stretch), and a 20% increase in elastic recovery (return to the starting point).⁶⁹ It is critical that further studies are performed utilizing objective measurements to continue to characterize this relationship.

When treating hypertrophic scars with AFL, both the CO₂ and Er:YAG platforms may be utilized. The various platforms differ in user interface, size of MTZs, ablation and coagulation profiles, and additional aesthetic capabilities. Laser surgeons choose the platforms they utilize based upon any number of these factors, in addition to their familiarity and comfort with the devices. Currently, there is a lack of strong evidence in the literature to support one platform over the other based upon efficacy in treating hypertrophic scars alone. Many experts primarily utilize ablative fractional CO₂ in their practices.

Pharmacotherapy

While the pathophysiology of scar formation remains incompletely understood, the fibroblast is identified as an important cellular target. By inhibiting fibroblast proliferation and cell division through the use of antimetabolic drugs, scars can be reduced in size and symptomatology.⁷⁰ The mechanistic process by which this occurs is poorly understood, though Col-1, TGF- β 1, and MMP-2 have been identified as significant targets.⁷¹ The two major classes of antimetabolic drugs are corticosteroids and antitumor agents. Although the use of intralesional corticosteroids is already common practice for many physicians, there is significant potential efficacy of combination therapy with other drugs, such as 5-FU.

Corticosteroids

Intralesional corticosteroid therapy (i.e., dexamethasone, triamcinolone) has long been the standard of care for hypertrophic and keloid scarring. Multiple studies show that this drug class consistently inhibits fibroblast cell growth and at high dosages induces fibroblast apoptosis.⁷⁰ However, inconsistent treatment sessions and inappropriate dosing are associated with treatment

failure, scar recurrence, and undesirable side effects such as epidermal atrophy, lipoatrophy, hypopigmentation, and telangiectasia formation. If patients are treated with intralesional corticosteroid monotherapy, it is important to educate them on the need for consistent follow-up and repeated treatments. Appropriate drug concentration selection should be based upon scar thickness and location and is expected to change (i.e., use of lower concentration) as the scar begins to atrophy. The precise volume of an intralesional corticosteroid injection required to induce atrophy is yet to be defined, but the clinical endpoint used by the authors is visual blanching of the scar. A conservative and cautious approach should be employed in thick scars where injections may be made at multiple levels and blanching may not always be observed.

5-Fluorouracil

5-FU is a pyrimidine analog that inhibits DNA synthesis in cells and is commonly used in antineoplastic therapy. In addition to inhibiting fibroblast proliferation and inducing fibroblast apoptosis, 5-FU has been observed to inhibit myofibroblast proliferation which is important in the prevention and treatment of scar contracture.⁷² In addition, at nontoxic levels 5-FU exhibits an anti-angiogenic effect, lending to utility in the treatment of keloid scarring.⁷³ In monotherapy, 5-FU at a concentration of 50 mg/mL with a total dose varying from 50 to 150 mg per session has been safely used at weekly intervals. The most common reported side effects were injection site discomfort and temporary injection site hyperpigmentation. Ulceration and sloughing occurred less frequently.^{72,74} In addition to intralesional injection, 5-FU has effectively been applied through a processing of “tattooing,” where locally anesthetized scars were treated by dripping 1 mL of 5-FU solution (50 mg/mL) onto each 1 cm² of the lesion, and then 40 punctures per 5 mm² were made on the lesions using a 27-gauge needle followed by repeated application of 5-FU.⁷⁵ This approach was found to be more effective than conventional intralesional triamcinolone injections.⁷⁵ Additional evidence of treatment effect has been observed using immunohistochemistry (IHC). Evaluation of treated scars using IHC revealed reduction in the Ki-67 proliferative index ($p = 0.0001$) as well as reduction in TGF- β .⁷⁴ Despite reports of clinical treatment success with the use of 5-FU, recurrence rates of up to 47% within the first year have been documented.⁷⁴

Corticosteroid/5-fluorouracil combination therapy

The use of combination intralesional corticosteroid/5-FU therapy has been associated with improved scar regression, reduced recurrence, and fewer side effects.^{43,73,76–78} This is thought to be due to the synergistic properties of these medications. Intralesional corticosteroids can inhibit fibroblast proliferation, enhance collagen degradation, and reduce cell migration. However, when used in combination with 5-FU, competitive inhibition of the synthesis of thymidylate synthase occurs, leading to a cessation of cell division.⁷³ This combination leads to the complete inhibition of type 1 collagen production. While multiple RCTs have shown success with this combination, therapeutic recommendations regarding drug concentrations are lacking. Initiating combination therapy with a 1:1 mixture of triamcinolone 40 mg/mL and 5-FU 50 mg/mL is a reasonable approach. Injection volume is limited to the amount required to induce visual blanching of the scar. Patients return to clinic for serial 4- to 6-week follow-up appointments. To avoid unwanted atrophy, the concentration of triamcinolone is subsequently reduced as scars flatten. For example, if a scar remains indurated but is only slightly elevated, a lower concentration of corticosteroid is preferred. This can be accomplished by altering the corticosteroid to 5-FU ratio (i.e., 1:3 concentration of triamcinolone acetonide 40 mg/mL: 5-FU 50 mg/mL). In addition, the use of PDL and intralesional therapy concomitantly is beneficial and has been previously reported in the literature.⁷⁹

Laser-assisted drug delivery

One of the greatest obstacles to effective topical pharmacotherapy has always been the inherent barrier function of the skin. AFLs create MTZs consisting of open vertical channels several hundred microns in diameter. These channels offer a novel delivery method for topical pharmacotherapy. Research in this area is burgeoning due to the highly localized and potentially efficacious nature of this route of administration. Characteristics of the vertical channels, such as diameter, and the ratio of ablation to coagulation highly influence the success of laser-assisted drug delivery (LADD). As this area is explored, optimal characteristics for vertical channel creation and medication delivery are being established. For example, it has recently been demonstrated that a small amount of coagulation around each vertical channel

favors better uptake.⁸⁰ Adjusted positive and negative pressure of the treated area after treatment may improve drug delivery as well.⁸¹

Medication uptake is also highly dependent upon the vehicle selected. For instance, it was recently shown that a liquid vehicle is considerably more efficacious than a gel.⁸² Other factors influencing medication uptake may include compound size, electrical charge, and osmolality. Unlike traditional routes of administration (oral, intravenous, and topical), the pharmacodynamics and pharmacokinetics of medications delivered via LADD are not well defined and suggest a need for continued research.

The number of pharmacotherapeutics utilized in LADD for hypertrophic scarring is rapidly increasing. Medications discussed both in the literature and scar symposiums include: corticosteroids (Fig. 63-8), 5-FU, bimatoprost, poly-L-lactic acid, timolol, and rapamycin.^{83–86}

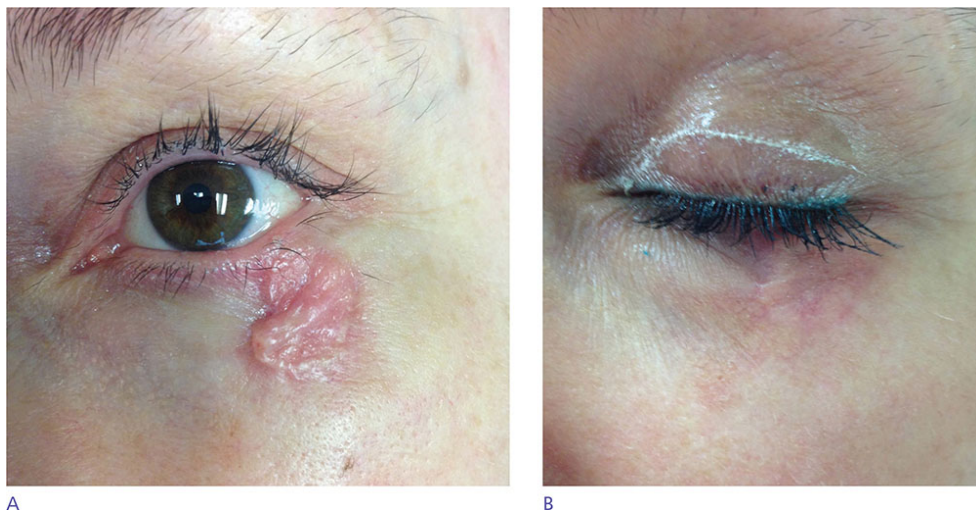


Figure 63-8. (A) Hypertrophic scar of the left lower eyelid after successful Mohs micrographic surgery with full-thickness skin graft repair. (B) Successful scar rehabilitation after two treatments with AFL and adjuvant LADD of 40 mg/mL of triamcinolone acetonide applied topically.

Empirically, physicians have applied medications within 2 minutes of the creation of the vertical channels in order to prevent obstruction of delivery secondary to serum migration into the channel and edema. However, a recent report shows that these channels may stay viable for drug delivery for hours after treatment.⁸⁷ A combination of triamcinolone and 5-FU (see Case C) may be applied within 5 to 10 minutes of channel creation. In addition, topical corticosteroids in ointment form may be used in lieu of petrolatum

within the first 24 hours to capitalize on the patent channels and simultaneously create an optimal wound-healing environment per standard practice. Although this practice is off-label, this technique provides a clinically effective adjunctive treatment to AFL.

LADD is in the early stages of evolution. As continued advances in delivery are made and our understanding of the basic science behind hypertrophic scars increases, LADD may play a larger role in hypertrophic scar management.

Surgical intervention

Scar excision and revision

Although scars are perceived as negative, they are an essential part of the human condition. After the early stages of fetal life, the human body can only heal injuries that penetrate the papillary dermis by forming a scar. While prevention of scar formation is unlikely, scar rehabilitation is available using modern techniques such as laser therapy, particularly in conjunction with well-planned surgical intervention following careful evaluation of the scar. Traditional treatment of posttraumatic and burn scars has centered around excision and primary closure with scar revision or excision and replacement with either grafts or flaps.⁸⁸

Laser therapies enhance the ability of scar tissue to remodel itself, and when necessary, tension relieving, carefully targeted, surgery is profoundly synergistic.⁵⁵ Well-healed and remodeled autologous tissue in the right location results in the most natural appearance and function for the patient with the least amount of morbidity (see Case B).

Z-plasty technique

There is a misconception that extensive surgery is required for extensive benefit in the hypertrophic scar population. Often, the simplest approach is best, including Z or W plasty in conjunction with AFL, PDL, and the adjunctive therapies reviewed above (see Cases A and B).⁵⁵

The Z-plasty is an essential tool in the management of posttraumatic and burn scarring. In addition to lengthening scars and relieving tension, it is also capable of lowering raised scars, elevating depressed scars, and possibly

obscuring the actual presence of a scar by mitigating scar perception through the elimination of straight lines, which is the concept behind camouflage.⁸⁹

The fundamentals of Z-plasty are simple and addressed at length in [Chapter 27](#).^{33,90} Two principles are worth emphasizing: Z-plasty performed within scars is virtually undetectable, and the resulting decrease in tension helps scar maturation, as demonstrated in Cases A and B. The use of Z-plasty, when necessary, in combination with the methods of laser therapy with or without LADD should decrease the indications for scar excision in the future.

Case A. Hypertrophic Burn Scars of the Face

A 5-year-old Italian male presented with facial hypertrophic scarring secondary to a gasoline flame burn injury 3 years prior. His contracted, hypertrophic scars remained erythematous, conspicuous, and symptomatic ([Fig. A-1](#)). When burns involve concave areas such as the glabella, lateral nasal walls, upper lip, and infra commissural area, it is common to develop bowstring hypertrophic scars. Z-plasties were designed to decrease tension and flatten the scars ([Fig. A-2](#)). Intraoperatively, immediate improvements in the tension of the scar can be appreciated ([Fig. A-3](#)). Concomitantly, nonoperated areas of the scar were treated with the 595-nm PDL utilizing a 7-mm spot size, 7.0 J/cm² fluence, a pulse width of 1.5 ms, and a DCD of 30/20. Two years later, the patient underwent two small Z-plasties along the lower lip and repeat PDL with similar settings and an increase in fluence to 8.0 J/cm² ([Figs. A-4 and A-5](#)). Two additional comparable PDL treatments were performed over the next 2 years, increasing fluence to 9.0 J/cm². Seven years after the initial treatment his facial scars are flat, soft, inconspicuous, and asymptomatic. No scar tissue was removed to achieve this outcome ([Fig. A-6](#)). This case exemplifies the synergistic effect of wound tension reduction and PDL in achieving a significant reduction in hypertrophic scarring secondary to thermal injury.



Figure A-1.



Figure A-2.



Figure A-3.



Figure A-4.



Figure A-5.



Figure A-6.

Case B. Hypertrophic Burn Scars of the Trunk

A 4-year-old male presented with hypertrophic scarring of the trunk following second- and third-degree scald burns from hot coffee 2 years prior. Conventionally, burn surgeons would typically suggest early intervention with excision and grafting to promote faster healing and a more favorable outcome. Due to a lack of access to care, the initial wound healed secondarily over a 3-month period without surgical intervention. The appearance of the resultant scar 2 years after the initial injury is shown in [Figure B-1](#). Thick hypertrophic scarring and contracture can be appreciated across the chest, particularly spanning the concavity between the deltoid prominence and the pectoralis major. Focal islands of normal skin within the scar appear as depressions. Reduction in elasticity and extensibility was noted within the hypertrophic scars.

Multiple Z-plasties were performed in order to separate the scar into smaller, discrete areas with focal reductions in tension (Figs. B-2 and B-3). A large Z-plasty performed in the deltopectoral groove significantly flattened the hypertrophic scar and relieved the contracture. Concurrent treatment of the scar with 595-nm PDL was performed, taking caution to avoid areas involved in the Z-plasties. PDL settings included a 7-mm spot size, 6.0 J/cm² fluence, 1.5-ms pulse width, and a DCD of 30/20. Over the following years, the patient underwent two smaller Z-plasty procedures and 21 PDL treatments approximately every 2 to 4 months with similar settings and gradually increasing fluences to 9.0 J/cm². After the ablative fractional CO₂ laser became available he had eight CO₂ treatments separated by 3 to 4 months. Settings for the deep ablative fractional CO₂ laser ranged from 15 to 40 mJ and 5% to 10% density. The density was decreased to 5% at a fluence of 40 mJ. Topical triamcinolone (10 mg/cc) was applied after treatment with the deep handpiece. Superficial ablative fractional CO₂ was performed with the Active hand piece with a fluence of 100 mJ and 150 to 200 Hz.

The resultant reduction in erythema and hypertrophy is demonstrated in Figure B-4. A small, focal area of hypertrophy can be appreciated over the sternum. This occurred as a result of an excessively dense treatment to the area with the ablative fractional CO₂ laser. Overall, the scars are flat, inconspicuous, and asymptomatic. The restoration of near-normal appearance is matched by the return of essentially normal elasticity. No scar tissue was removed to achieve this outcome. This case exemplifies that a multimodal approach can achieve great benefit but it may require numerous iterations of therapy.



Figure B-1.

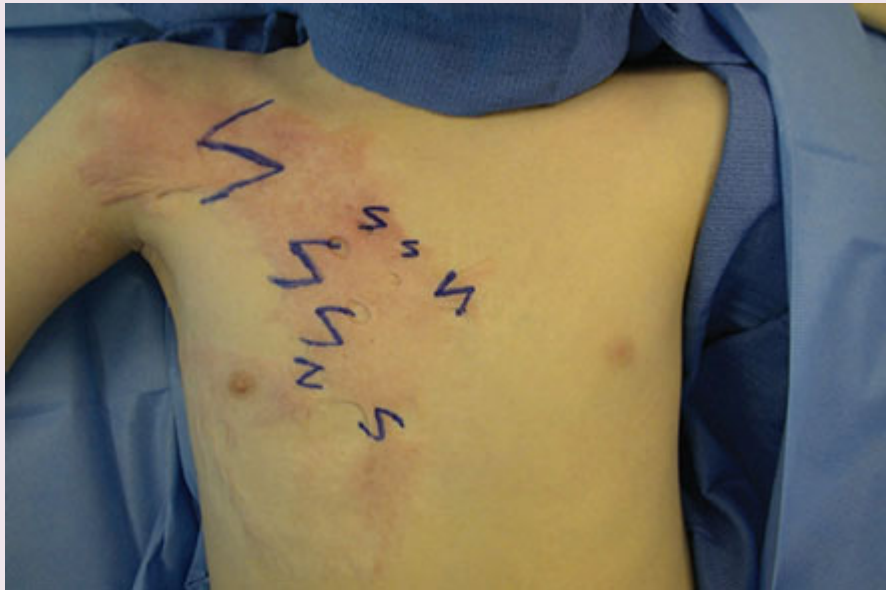


Figure B-2.



Figure B-3.



Figure B-4.

Special considerations

In addition to the therapies above, polytrauma and burn patients often require special considerations. In these populations, retained pilosebaceous units and traumatic amputation may have an additional impact upon health-related quality of life.

Retained pilosebaceous units

First- and second-degree burns have the potential to heal with intact follicular units that are overgrown by scar formation (Fig. 63-9). The retained keratin leads to a foreign-body reaction with resultant inflammation and pustule formation. Inflammation subsequently compromises skin integrity, and affected sites become potential niduses for infection. Alleviation of this condition can be accomplished with ablative fractional resurfacing, which provides an avenue for the hair to escape, eliminating the foreign-body reaction. This approach has been shown to be useful in hair-bearing areas in which the liberated hair helps mask scars and improve cosmesis.⁹¹

Alternatively, laser hair removal may be utilized to remove problematic follicular units, but is limited by the ability of a laser light to penetrate thick scars (Fig. 63-10). This approach may also lead to irritation, as the destroyed keratin will be retained locally until cleared by the patient's immune system. This method is better utilized in patients with full-thickness skin grafts from hair-bearing sites which have been placed in areas where hair is not desired, such as the hands. The correct choice will depend upon patient presentation.

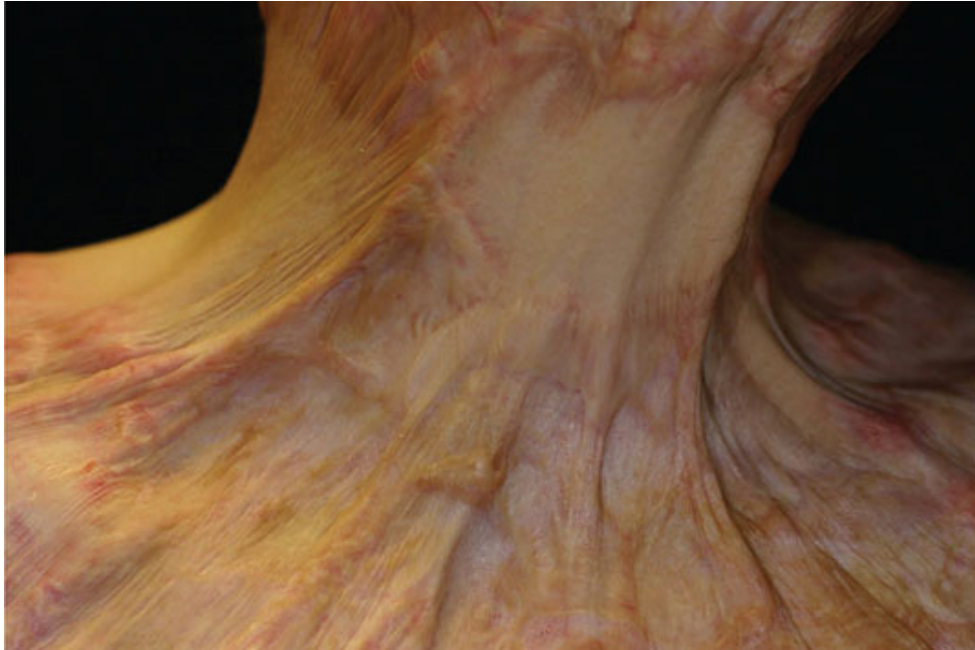


Figure 63-9. Hypertrophic scarring of the face due to first- and second-degree burns. Note the intact hair follicular units visible within the skin.



Figure 63-10. Extensive scarring of the scalp with retained follicles resulting in a foreign-body reaction and skin compromise. Laser depilation of the scalp resolved this condition and achieved an aesthetic outcome satisfactory to the patient.

Traumatic amputation

Patients with traumatic amputations and scarring at the residual limb report a 60% rate of skin issues related to the pilosebaceous unit and excessive sweating that directly interferes with prosthetic utilization.⁹² In addition to the treatment of the traumatic scars, laser hair removal to the residual limb has been shown to greatly reduce the complaints related to the pilosebaceous unit such as folliculitis, pseudofolliculitis, pruritus, cutaneous pain, skin erosion, and infection. Optimization of this interface significantly improves prosthetic usage and health-related quality of life (Fig. 63-11).⁹³ Botulinum toxin may also be used in order to reduce sweating at the residual limb, which also improves fit and function of the residual limb.⁹⁴

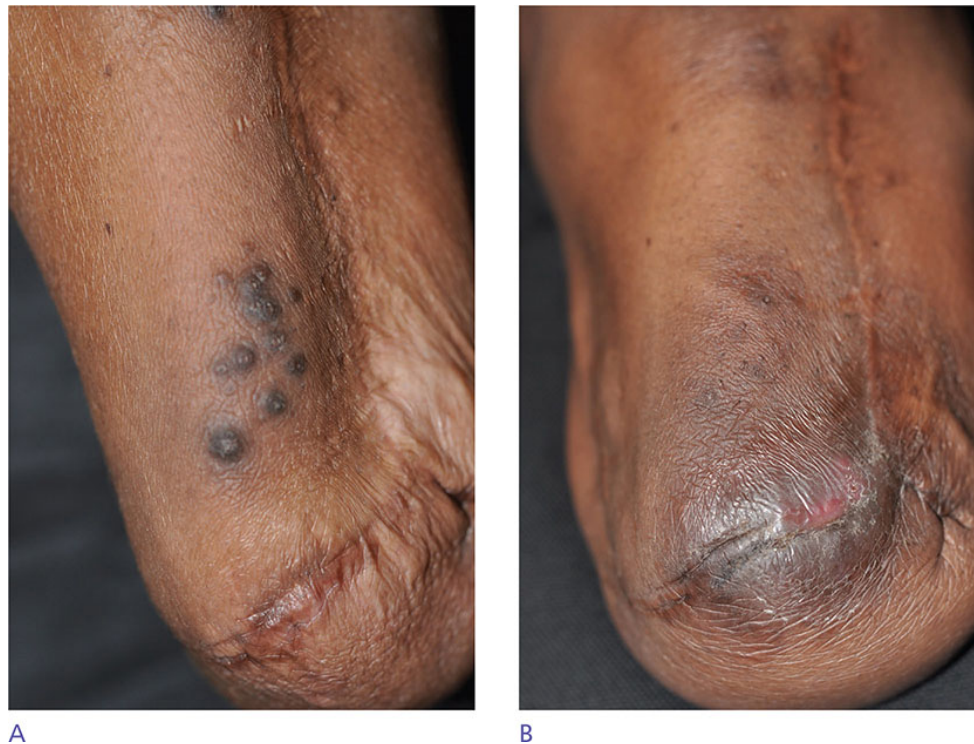


Figure 63-11. (A) Pseudofolliculitis of the residual-limb–prosthetic interface resulting in perifollicular papules and discomfort secondary to chronic friction. (B) Resolution of perifollicular papules 4 weeks after one treatment of laser hair removal and AFL to the affected area.

STEP-BY-STEP TREATMENT INSTRUCTIONS

Patient expectations

Establishing and managing patient expectations is an integral aspect of clinical care. Given the complexity of hypertrophic scar management and the general lack of awareness of the available treatment options and associated outcomes by the patient, it is essential to incorporate this discussion during the clinical evaluation. The understanding of the patient's needs and expectations by the physician produces greater satisfaction of care, which has been correlated with greater adherence to therapy, less doctor shopping, and a lower propensity to sue for malpractice.⁹⁵ The counseling physician will occasionally be met with unrealistic patient expectations and should be prepared to educate the patient appropriately. This exchange enhances the patient's active role in the medical relationship, which may promote better outcomes.⁹⁶

Expectations related to symptom management and potential improvement in aesthetics and function should be discussed in the setting of hypertrophic scarring. Often, patients with extensive hypertrophic scars secondary to burns and trauma experience surgical fatigue due to the volume of procedures undergone and subsequent recovery time. When counseling these patients, it is important to stress the effective, minimally invasive nature that laser surgery offers. Coupled with a limited timeframe of recovery, laser surgery offers an additional safe and effective treatment option for patients with surgical fatigue.

In addition to expected outcomes and sequelae, providing information regarding the overall structure of appointments, office flow, and personnel involvement in the proposed treatment plan is an important factor in patient satisfaction, especially if the treatment course involves a multi-disciplinary team or a large medical facility.⁹⁵

Scar assessment

Hypertrophic scar extent and severity varies widely among patients presenting to the dermatologic surgeon for management. For limited or focal hypertrophic scarring, assessment and quantification of improvement is often

assessed by history and physical exam without obtaining objective measures of change within the scar. Extensive or debilitating hypertrophic scarring greatly benefits from the use of objective quantification methods. Objective and subjective measures used in the clinical evaluation of scars are outlined below.

Subjective measures

History. Obtaining a thorough history is critical to the evaluation and treatment approach of hypertrophic scars. The physician should collect information regarding the mechanism of injury, scar age, location(s), associated symptoms, and impact upon mental health. Previous treatments from the acute, subacute, and chronic phases of management should also be discussed. Common interventions include skin grafting, scar excision, Z-plasty, physical therapy, occupational therapy, intralesional pharmacotherapy, microneedling, and laser surgery. The efficacy of the previous treatments and future treatment expectations should be discussed thoroughly.

Physical examination and scar assessment scales. Physical examination without the aid of objective measurements tools should be considered a subjective physical assessment. The most commonly used scales are the VSS and the POSAS. The VSS and POSAS are well-established, standardized tools to assess traumatic scar quality.⁹⁷ Physicians use both scales to assess vascularization, pigmentation, thickness, relief, and pliability of the scars utilizing a visual analog scale. An additional benefit to the POSAS is the patient assessment scale that includes their perception of color, stiffness, thickness, irregularity, pain, itch, and symptoms.⁹⁸ Placing weight upon the patient's responses ensures maximum patient satisfaction.

When evaluating the patient, it is important to place the scars in positions of maximum tension or discomfort for appropriate evaluation. Placing the scar in positions of maximum tension may reveal scar blanching and contracture prominence indicating the need for additional depth of AFL in these areas (Fig. 63-12). Revealing maximum disability of the scar permits optimal assessment using the endpoints discussed. Should the physician not choose to utilize a scar assessment scale, the variables listed above still serve as appropriate endpoints to monitor and reveal areas of focus based on patient perceived severity.



Figure 63-12. Burn patient with contracted oral commissure and diminished oral opening. Note the white bands on the lateral aspect of the oral commissure. Although it is difficult to visually appreciate hypertrophy, palpation reveals thickened, dense scarring. Palpation is vital to fully assess scars.

Objective measures

The number of tools available to the dermatologic surgeon to objectively assess the skin is rapidly expanding. Although they have primarily been used for research purposes, clinical utilization in order to optimize and quantify patient outcomes has become increasingly prevalent in the treatment of hypertrophic scars.

Physical characteristics

Thickness and volume. Scar thickness, density, and volume are difficult to measure on inspection, as a portion of the scar exists below the skin surface.⁹⁹ High-frequency ultrasound provides reliable, accurate, noninvasive measurement of scar thickness allowing for titration of treatment and measurement of progress (Fig. 63-13).¹⁰⁰ Devices available include the Derascan (Cyberderm, Media, PA) and the more portable tissue ultrasound

palpation system (TUPS).^{100,101} Three-dimensional ultrasound is available for clinical use but may be cost-prohibitive.¹⁰¹ Accurate determination of scar thickness allows for appropriate titration of depth of the AFL and quantification of treatment efficacy.

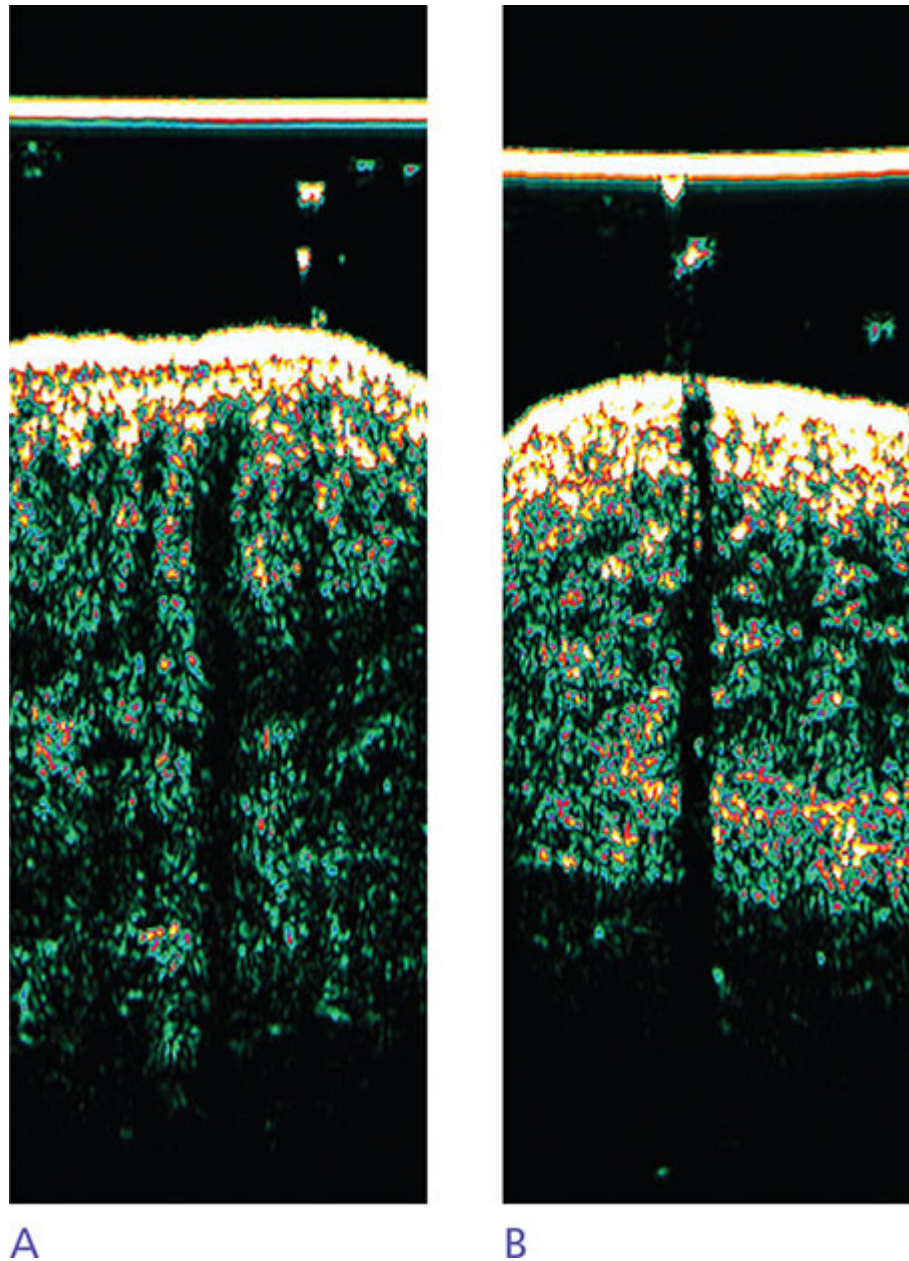


Figure 63-13. High-resolution ultrasound images of a hypertrophic scar before and after three treatments of fractionated CO₂ laser. (A) Mature hypertrophic burn scar. (B) Scar post-AFL: significantly decreased scar thickness with increased signal intensity (density) likely secondary to the remodeling process.

Mechanical function. Mechanical function of the skin is primarily measured by elasticity, extensibility, and stiffness. These variables are all defined by the application of a deformational force to the skin. Once the deformational force is applied, elasticity refers to the ability of the skin to return to its original shape, extensibility is the maximum amount of stretch demonstrated, and stiffness is the amount of resistance the skin demonstrates.¹⁰² Devices commonly utilized to measure these variables include the Dermal Torque Meter (Dia-Stron Ltd.) and the Cutometer (Courage + Khazaka).¹⁰² These devices are particularly effective in correlating subjective improvements in the relief and pliability endpoints of the POSAS with objective quantification. For severely impaired range of motion or scars extending across the joint, additional referral to physical therapy for goniometry, the measurement of total available motion of a joint, is recommended.

Color evaluation. Color is often the most difficult scar variable to assess due to the heterogeneous nature of hypertrophic burn and trauma scars and the variation in appearance due to environmental factors. Evaluation of color centers around erythema and pigmentation, with most devices measuring the reflectance and absorption of light in a focal area of assessment.¹⁰² Unfortunately, this does not allow for comprehensive scar color assessment due to inherent limitations of the measurement. Devices such as the DSM II ColorMeter (Cortex Technology), Minolta Chromameter1 (Konica), and Micro Color (Dr. Lange GmbH) are widely available for use. The DSM Colormeter has been shown to reliably assess vascularization and pigmentation in scar evaluation and significantly correlates with the POSAS.¹⁰³ Newer methods of color evaluation utilizing computer analysis of images appear promising and allow for more global assessment of color and monitor improvement.¹⁰⁴

Laser safety

A protocol that promotes the safety and well-being of the laser surgeon and the patient should be established in every practice. Stringent procedural safety guidelines may seem inconvenient, but have a proven record of risk reduction.¹⁰⁵ With reports of fire caused by PDLs and the risk of the laryngeal papillomatosis caused by aerosolized viral particles in laser-

generated smoke, it is clear that laser safety is paramount.¹⁰⁶ The Occupational Safety and Health Administration (OSHA) provides specific information regarding workplace hazards and appropriate countermeasures related to medical laser use.¹⁰⁷ Categories of safety concern include: severe eye injuries from direct or reflected laser light, skin burns from misdirected beams of surgical lasers, and respiratory hazards from breathing laser-generated airborne contaminants.

The American National Standard Institute (ANSI) Z136 series of laser safety standards provides guidance for the safe use of lasers in diagnostic, cosmetic, preventative, and therapeutic applications in health care facilities.¹⁰⁸ These guidelines are considered to be the standard for safe practice and are recommended for review and implementation. These standards can be incorporated into a laser safety program that may also include standardized laser safety training for all providers, nurses, and other allied health professionals working with laser equipment, annual training reviews, quarterly self-inspections, and incorporation of pre-procedure laser safety checklists.

Laser surgery

Selective photothermolysis of vasculature

There are several devices available to treat vascular and immature hypertrophic scars; the PDL, the KTP, and IPL. With the largest amount of evidence for the treatment of hypertrophic scars, the PDL is the most widely adopted vascular laser. The treatment concepts below apply to all devices targeting the vasculature, although exact treatment parameters will vary.

Pulsed-dye laser (595 nm). The VBeam Perfecta (Syneron Medical Ltd., Yokne'am Illit, Israel) utilizes an organic dye as the laser medium and generates laser light at the 595-nm wavelength. Pulse width selection ranges from 0.45 to 40 ms. Spot sizes range from 3 to 12 mm in diameter and can generate maximum fluences of 40 J/cm² and 7 J/cm² at each spot size extreme.¹⁰⁹ With increasing spot size, less fluence is required to achieve similar outcomes due to the optics of the skin. Epidermal cooling is achieved via a cryogen spray.¹⁰⁹ Pulse control can be achieved by either foot switch or finger switch depending upon the preference of the laser surgeon.

Alleviation of preprocedural anxiety will increase patient tolerance and treatment success. Despite protective eyewear, the patient may appreciate bright flashes of light during the procedure and should be cautioned.

Treatment protocol

Contraindications: Patients with a past medical history of diseases that carry a risk for koebnerization, such as vitiligo and psoriasis, may experience worsening of their conditions with laser therapy.

Informed consent: Informed consent is necessary for the patient to fully understand the risks, benefits, and alternatives to laser treatment. Table 63-1 includes a general list of considerations for informed consent. The individual laser surgeon should tailor the consent form to their specific device and patient population.

Table 63-1. Laser Surgery Consent Form Considerations

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- A. Patient identifiers
 - B. Name of the treating physician and diagnosis
 - C. Authorization for procedure(s) to be performed and device(s) used
 - D. Alternative treatments disclosure
 - E. Anesthesia consent
 - F. Proposed treatment results
 - G. Disclosure of laser specific risks
 - H. Photography permissions
 - I. Informed consent
-

The patient should initial each paragraph and sign the document with a witness present.

Prophylaxis: Not indicated. Unlike AFL, typical PDL treatment of hypertrophic scars does not result in compromised skin integrity that would necessitate prophylaxis with antimicrobial medications.

Analgesia: PDL treatment does not typically require analgesia. If desired, 4% to 7% topical lidocaine may be applied with or without occlusion for 30 to 60 minutes prior to treatment. With the exception of pediatric or extensive cases, general anesthesia is not indicated.

Site preparation: The treatment area should be thoroughly cleansed prior to treatment. Special attention must be paid to the face. Patients will often apply cosmetics or topical agents with tinted bases that can greatly impact therapy or result in unwanted complications.

Spot size (mm): Spot size should be titrated to the size of the scar with an additional 2 to 3 mm overlap of surrounding unaffected skin. When treating extensive scarring, larger spot (10–12 mm) sizes will help facilitate efficiency of treatment for both the patient and the laser surgeon.

Pulse width (ms): When performing selective photothermolysis, the pulse width should not exceed the thermal relaxation time of the target, which is directly proportional to its diameter. Failure to adhere to this principle may result in thermal injury to the surrounding dermis that may lead to further scarring. Studies have shown pulse widths of 0.45 to 1.5 ms to be most effective when targeting the fine vasculature present in hypertrophic scars.⁵⁵

Fluence (J/cm^2): The fluence should be conservative yet sufficient to elicit mild purpura lasting less than 3 to 5 seconds. Goal fluences range from 4.5 to 6.5 J/cm^2 .^{2, 49} Excessive purpura may result in hemosiderin deposition, which is difficult to eliminate.

Dynamic cooling device (DCD): We recommend setting the DCD to a 30-ms delay duration and 30-ms spray duration, also known as, 30/30. DCD postspray duration is not necessary.

Technique: In order to ensure appropriate function of the DCD and uniform delivery of laser light, the handpiece should always be placed perpendicular and flush to the skin. Due to the topographic irregularities of scars, laser surgeons employing the use of devices with contact cooling must be especially cautious during treatment. Failure to achieve epidermal cooling may lead to thermal injury of the epidermis.

Postoperative care: A cold pack or plastic bag filled with ice and wrapped in a damp towel should be applied to the area for 5 to 10 minutes after treatment to minimize swelling. After PDL monotherapy, recovery should be nearly immediate. If persistent purpura does occur, resolution should be achieved in 3 to 5 days.

Treatment intervals: Treatments should be performed at 4- to 6-week intervals.

Complications: Temporary postprocedure erythema is expected. Complications from PDL treatment of hypertrophic scars are rare but may

occur if DCD is not engaged. Without epidermal cooling, extensive purpura or bullae may develop. In both instances, conservative management is recommended with petrolatum-based ointments and sun avoidance.

Ablative fractional photothermolysis

There are a number of AFLs available on the market that utilize either CO₂ or Er:YAG as the laser medium.¹¹⁰ The pulsed, ablative fractional CO₂ laser was initially adopted in the military setting for cosmetic training of medical residents following early reports that indicated greater collagen growth with the pulsed CO₂ compared to the scanned CO₂ or Er:YAG systems.¹¹¹ Military and civilian dermatologic surgeons began clinical studies using fractional CO₂ in patients with trauma and burn scars, largely contributing to the prevalence of its use today.^{112,113} Of the ablative fractional CO₂ lasers available, the Lumenis UltraPulse platform (Lumenis Ltd., Yokne'am, Israel) has the greatest support in the literature for the treatment of hypertrophic scars. Although specific treatment parameters will differ, the treatment concepts discussed apply to all AFLs.

Ablative fractional carbon dioxide (CO₂) laser 10,600 nm. The Lumenis UltraPulse CO₂ laser offers both superficial and deep fractional ablation. The pulse width is fixed at 0.8 ms, just below the 1-ms thermal relaxation time of the skin.¹¹⁴ This pulse width ensures that there is a narrow rim of thermal coagulation around the zone of ablation. Treatment is delivered using a stamping technique. The DeepFX UltraPulse configuration is utilized to achieve deep AFL treatment consisting of columns of ablation that measure 120 microns in diameter. The density of these columns is determined by the laser surgeon and varies depending upon the goal of treatment. The depth of penetration is directly proportional to the fluence selected and ranges from 75 microns to 4 mm using the SCAAR FX treatment mode. The goal of deep AFL is the removal of scar tissue in order to facilitate remodeling and neocollagenesis.

The ActiveFX UltraPulse configuration can be used to achieve superficial fractional ablation. The ActiveFX treatment mode generates a 1.3-mm spot size and delivered energy ranging from 2 to 225 mJ. Density ranges from 55% to complete ablation. The maximum depth of penetration is approximately 250 microns. With both configurations, the frequency or rate

of energy delivered may be adjusted to minimize or maximize the speed of treatment and bulk heating. Pulse delivery is achieved using a foot pedal.¹¹⁵ The goal of superficial AFL is to minimize scar surface irregularities and ensure blending of deep AFL treatment.

Treatment protocol

Contraindications: Patients should not be treated if they have active infections of the skin, diseases such as vitiligo or psoriasis that may koebnerize, treatment with isotretinoin within the last 6 months, or conditions that may inhibit wound healing.

Informed consent: As with the PDL, informed consent is required to ensure the patient fully appreciates the risks, benefits, and alternatives to AFL treatment. Sufficient time should be allotted to fully ensure patient understanding. With AFL, the patient should also understand that it may take several months to appreciate the maximum benefit of treatment as new collagen will continue to form for up to 6 months after therapy.¹¹⁶ The informed consent process must be complete prior to prescribing medications for anxiolysis or analgesia. Of the preventable forms of legal action against the laser surgeon, the most common is a failure to obtain proper informed consent.¹¹⁷ Table 63-1 includes a general list of informed consent considerations. The individual laser surgeon should tailor the consent form to their specific device and patient population.

Prophylaxis: Treatment with ablative fractional CO₂ laser creates thousands of MTZs that serve as potential ports of infection into the skin. As such, antimicrobial prophylaxis plays an important role in AFL therapy. In patients with facial scarring and patients with a history of genital herpes, valacyclovir 500 mg is dosed twice a day for 10 days starting the night before the procedure. Antifungal prophylaxis is achieved with fluconazole 200 mg taken on the morning of the procedure and repeated 1 week later. Some laser surgeons employ the use of oral antibacterial prophylaxis; however, many feel this may result in the promotion of atypical infections.¹¹⁸ If a patient has a history of methicillin-resistant staphylococcus aureus infections, the authors prescribe oral antibiotics with gram-positive coverage, most commonly doxycycline 100 mg twice a day starting the night before treatment.

Despite prophylaxis, infection rates in the cosmetic resurfacing population have been reported as high as nearly 10%.^{60,119}

Anxiolysis: A small percentage of patients may experience significant pre-procedural anxiety. In these patients, a one-time dose of diazepam (5–10 mg orally) or lorazepam (1–2 mg orally) can be given before the procedure. Ensure that the consent form has been completed prior to treatment.

Analgesia: AFL treatment can be painful and may require topical cooling, topical anesthesia, conscious sedation, or general anesthesia depending upon the extent of scarring and the patient. Typically, topical, local, and/or tumescent anesthesia are sufficient to achieve adequate analgesia for the majority of cases performed by the dermatologic surgeon. Rarely, cases may require general anesthesia.

Cold therapy using contact cooling, cryogen sprays, ice packs, or cool air devices can be helpful in the reduction of operative and postoperative discomfort. In our practice, a Zimmer Cryo Cold Air Device (MedizinSysteme) is utilized throughout the procedure.

Commonly used topical anesthetics include 4% lidocaine (LMX), lidocaine 2.5%/prilocaine 2.5% (EMLA), and compounded benzocaine 20%/lidocaine 6%/tetracaine 4% (BLT). Topical anesthetics should be applied liberally to the treatment area for 30 to 60 minutes prior to treatment and can be occluded with plastic wrap to increase effectiveness. Extreme care should be taken in patients with large treatment areas or those taking medications that inhibit the hepatic clearance of lidocaine, as systemic lidocaine toxicity has been reported with topical lidocaine in patients being treated with AFL.¹²⁰

Local anesthesia is commonly achieved utilizing lidocaine 1% with epinephrine 1:100,000 compounded with 8.4% sodium bicarbonate in standard fashion for both focal numbing and ring blocks (Case C). Lidocaine 1% to 2% without epinephrine is also useful for nerve blocks, particularly for the face. Tumescent anesthesia may also be utilized in the standard fashion. Conscious sedation, also referred to as moderate sedation/analgesia, is another option for procedural sedation and can be achieved by the experienced and credentialed provider with medications including benzodiazepines, opiates, ketamine, and propofol. Conscious sedation should always be performed in an environment with appropriate equipment, monitoring, and physician capability.

If general anesthesia is required for treatment, the dermatologic surgeon will have the benefit of an anesthesia provider to assist in the management of

the patient. In this environment, special care must be taken to avoid ignition of the endotracheal tube during CO₂ laser surgery.^{121–123} If the treatment area includes the head or neck, asking the anesthesia provider to lower the patient's inspired oxygen concentration to that of room air equivalent (21%) to minimize the possibility of a combustive event may be beneficial.

Special considerations: Studies have shown a number of carcinogens and potentially infectious agents in plumes generated by the CO₂ laser.^{124,125} A surgical smoke evacuators held 2 in away from the treatment site may be useful. In addition to reduction of the laser plume, the use of a smoke evacuator also reduces treatment odor, which may lead to PTSD exacerbation in burn patients.

Site preparation: The treatment area should be thoroughly cleansed prior to treatment. Special attention must be paid to the face. Patients will often apply cosmetics or topical agents with tinted bases that can greatly impact therapy or result in unwanted complications.

Deep AFL (DeepFX):

- a. Spot size: Contour directly to the size and shape of the scar. There are four patterns and six size options available with this device.¹¹⁵
- b. Pulse width (ms): Fixed, as outlined above.
- c. Energy (mJ): Should be titrated to the thickness of the scar, with a goal of at least 80% penetration. Each platform will have a chart demonstrating the relationship between depth and energy level. It is recommended that the laser surgeon review the chart for their device.
- d. Density: Lower densities (5–15%) appear to be of greater benefit when treating hypertrophic scars. A 5% density may be preferred, and two passes at 5% may be used if a higher density of treatment is desired.
- e. Frequency: Represents the delivery rate of the MTZs. Decreased frequency anecdotally decreases the pain associated with treatment and helps prevent the delivery of an excessive amount of heat per area treated. Excessive density and/or frequency may lead to bulk heating that can result in pigmentary abnormalities and injury to the skin.
- f. Endpoint of treatments: Deep ablative fractional photothermolysis does not have a visible treatment endpoint. Ensure the entire scar and 1 to 2 mm of surrounding normal skin is treated with minimal overlap.

Superficial AFL (ActiveFX):

- a. Spot size: Contour directly to the size and shape of the scar. There are seven patterns and nine different size options available.
- b. Pulse width (ms): Fixed, as outlined above.
- c. Energy (mJ): May vary depending upon the location and thickness of the scar. Typical treatments range from 80 to 125 mJ, which correlates with depths of approximately 50 to 115 microns.
- d. Density/Treatment level: It is important to ensure treatment remains fractional. The authors commonly use a treatment level of 2 (55% density) when treating hypertrophic scars.
- e. Frequency: Decreased frequency is also employed with the superficial ablative laser to minimize excessive heating and pain.
- f. Endpoint of treatments: Superficial ablative fractional photothermolysis does not have a visible treatment endpoint. Ensure complete coverage of the affected area.

Treatment intervals: Although there are no studies evaluating treatment intervals, the authors use an interval of 3 months to allow sufficient remodeling of the hypertrophic scar.

Postoperative care: Table 63-2 provides a detailed review of care following AFL treatment.

Table 63-2. Ablative Fractional Carbon Dioxide Laser Aftercare

Immediate aftercare	Apply a cold pack to the treatment area for 5–10 minutes. Caution should be taken as excessive cold application may compromise skin integrity or result in dyschromia. Topical white petrolatum or Aquaphor® (Beiersdorf, Wilton, CT) should be applied to the treated area. Alternatively, a one-time application of topical triamcinolone or clobetasol ointment may be used.
Home aftercare	Cold soaks with 1 teaspoon of white vinegar to 1 cup of water or aluminum acetate (Domeboro, Bayer HealthCare, Morristown, NJ) should be conducted 3–4 times per day for antiseptis and reduction of erythema and edema. Reapplication of petrolatum-based ointment should be performed following each cold soak. Continue to take antimicrobial prophylaxis as directed.
Patient education	Mild flaking to moderate peeling of the surface layers of the skin can be expected during the healing process. Scratching, picking, or abrading the area may cause unwanted scarring or hyperpigmentation. Oral over-the-counter analgesics may be used for mild discomfort. Moderate to severe pain, particularly around 4–5 days postprocedure, should be seen in the office to assess for risk of infection. Avoidance of direct sun exposure and use of sunblock is recommended to reduce the risk of postprocedure hyperpigmentation. Avoid potential environmental irritants during the healing process such as topical cosmetics, hairspray, dust, and dirt.
Follow-up	Seven day in office follow-up is recommended to assess for infection and progression of healing.

Complications: Adverse events of AFL treatment include infection, scarring, ectropion, koebnerization of underlying skin disease, hyperpigmentation, contact dermatitis to topicals, and prolonged

erythema.^{126,127} Management is typically conservative and targeted to the complication.

Case C. Iatrogenic Hypertrophic Scarring

A 51-year-old female presented 9-months status post wide local excision and split-thickness skin grafting for recurrent malignant melanoma in situ within the left popliteal fossa. Her postoperative course was complicated by partial (20%) graft loss, granulation tissue formation treated with multiple iterations of silver nitrate, and allergic contact dermatitis to bacitracin. On presentation, she reported a gradual increase in pain, increased scar formation, and decreased range of motion since the original procedure. Her split-thickness skin graft exhibited significant hypertrophic scarring associated with hyperpigmentation and irregular surface changes (Fig. C-1). Numerous fibrotic and tethered sclerotic cords were appreciated on palpation and associated with significant discomfort, especially on ambulation and prolonged sitting.

A thorough discussion of ablative fractional resurfacing, intralesional kenalog/5-FU injections, and postfractional application of topical triamcinolone acetonide was conducted. A compound cream of bupivacaine (4%), lidocaine (6%), tetracaine (6%) was applied under occlusion for approximately 45 minutes (Fig. C-2). The skin was subsequently cleaned with acetone and a ring block was performed using 6 mL of a buffered 1% lidocaine with epinephrine 1:100,000 diluted 10:1 with 8.4% sodium bicarbonate (Fig. C-3). Areas of predominant hypertrophic scarring were treated with the Lumenis UltraPulse Encore CO₂ with the DeepFX handpiece at 35 mJ, 5% density, 250 Hz and the remaining areas were treated at 20 mJ, 5% density, 250 Hz (Fig. C-4). ActiveFx was then used for field treatment at 100 mJ, treatment level 2 and 200 Hz especially at the periphery of the thicker areas (Fig. C-5). A 1:1 mixture of triamcinolone 40 mg/mL and 5-FU 50 mg/mL was injected using a 30-gauge needle directly into the sclerotic cords (Fig. C-6). Triamcinolone 40 mg/mL was then massaged into the treatment area prior to coverage with petrolatum and

a nonadherent dressing. At the 1-week postprocedure telephone follow-up, the patient reported a 75% improvement in range of motion, decreased pain, and denied issues or concerns with postprocedural healing. This case demonstrates a common, multimodal approach for the treatment of hypertrophic scars that can be performed comfortably using topical anesthesia.



Figure C-1.



Figure C-2.



Figure C-3.



Figure C-4.



Figure C-5.



Figure C-6.

Case D. Traumatic Hypertrophic Scarring

A 25-year-old marine sustained a severe thermal injury to the hand secondary to an ignited flare that resulted in significant soft-tissue scarring and banding without underlying bony changes. Nine months after the injury, no further gains in the range of motion were appreciated by physical and occupational therapy. [Figure D-1](#) demonstrates the thick, indurated scar with chronic eschar that has persisted since the initial injury. Preoperative assessment of pain and range of motion decrement, especially in cases of hypertrophic scars to the hand or foot were performed with and without palpation to adequately assess impairment. The patient underwent a total of two AFL treatments. [Figure D-2](#) demonstrates the treated area 1-week status post Lumenis Ultrapulse Encore CO₂ Deep FX treatment with 40 mJ; 5% density with two passes with 200 Hz with triamcinolone acetate 40 mg/mL dripped and massaged into the wound. Resolution of the eschar and near-normal range of motion was appreciated 3 months post initial laser

treatment (Fig. D-3). The second treatment was performed 4 months following initial treatment at 50 mJ; 5% density with two passes at 250 Hz with ILK 40 mg/mL dripped and massaged into the treated area. Following treatment completion, full range of motion was regained and the patient denied further pain or discomfort to the area. This allowed the Marine to return to full-time duty with no restrictions. This case exemplified the symptomatic and functional (i.e., range of motion) benefits associated with AFL treatment and LADD.



Figure D-1.



Figure D-2.



Figure D-3.

Multimodal approach

Laser surgery represents one modality utilized in the management of hypertrophic scars. When performing multiple procedures during the same treatment session, it is important to begin with the surgical interventions (Z-plasty), followed by PDL, then deep AFL treatment, followed by superficial ablative laser treatment with or without drug delivery, and finally intralesional pharmacotherapy. Adjuvant laser hair removal and botulinum toxin may also be utilized in the case of traumatic amputations.

CONCLUSIONS

Scars are a significant problem in both the civilian and military communities, and the functional and psychological impact of hypertrophic scarring cannot be overstated. By utilizing an aggressive approach to scar management, including laser devices as well as traditional approaches relying on intralesional and topical therapies, dermatologic surgeons have the ability to have a significant, meaningful, and lasting impact on these patients' lives.

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CHAPTER 64 Lasers for Vascular Lesions

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SUMMARY

- Laser therapy for vascular lesions targets oxyhemoglobin as the chromophore, with absorption peaks at 418, 542, and 577 nm.
- Blood vessel depth, thickness, and skin type are factors that are often considered for each patient.

Beginner Pearls



- Several types of lasers are available for the treatment of vascular lesions, including the pulsed dye laser (PDL); potassium titanyl phosphate (KTP) laser; neodymium:yttrium aluminum garnet (Nd:YAG) laser; CO₂ laser; argon laser; copper vapor laser; and intense pulsed light (IPL).
- PDL is currently the treatment of choice for PWS due to the low risk of scarring and acceptable complication rates, despite a relatively modest degree of total clearance, at approximately 15% to 20%.

Expert Pearls



- Rosacea and diffuse erythema have been successfully treated with PDL, IPL, and long-pulsed Nd:Yag (532 nm) lasers.
- A combination of lasers, phlebectomy and sclerotherapy may be the best long-term approach for treating leg veins, though as a monotherapy, sclerotherapy remains the gold standard treatment for leg veins.

Don't Forget!



- Purpuric settings consist of a single pass with shorter pulse durations (0.45, 1.5 ms) and higher fluences.
- Nonpurpuric settings require multiple passes with longer pulse durations (6 ms) and lower fluences.

Pitfalls and Cautions



- Given the widespread use and high success rates with using topical and oral beta blockers, laser treatment for HOI is becoming less common.
- When KTP lasers are used for leg veins, hyper- and hypopigmentation have been reported to occur in 20% to 40% of patients.
- Caution must be taken with multiple passes, which can result in vessel rupture with subsequent hemosiderin deposition with long-pulsed Nd:Yag lasers.

Patient Education Points



- Patients should understand the risks of laser treatment, including dyspigmentation.
- It is important that patients understand that most laser treatments involve multiple visits.

Billing Pearls



- Almost all insurers in the United States exclude laser treatments from coverage.
- Patients may benefit from committing to a series of treatments, as this may allow significant cost savings.
- Pre-treatment with occluded topical anesthesia can be started at home, and prescription plans may cover the cost of this medication.

CHAPTER 64 Lasers for Vascular Lesions

INTRODUCTION

Laser therapy for vascular lesions targets oxyhemoglobin as the chromophore, with absorption peaks at 418, 542, and 577 nm. One of the main goals in laser therapy is to focus the laser on its desired target with minimal effect on normal skin, including melanocytes and hair follicles.¹ Blood vessel depth, thickness, and skin type are factors that are often considered for each patient.

Types of lasers available for the treatment of vascular lesions

Several types of lasers are available for the treatment of vascular lesions, including the pulsed-dye laser (PDL); potassium titanyl phosphate (KTP) laser; neodymium:yttrium aluminum garnet (Nd:YAG) laser; CO₂ laser; argon laser; copper vapor laser; and intense pulsed light (IPL).

CO₂ and argon lasers are mainly of historical interest, as the scarring and skin texture changes seen with these treatments mean that they are not generally used to treat vascular lesions. PDL has been used to treat vascular lesions such as port-wine stains (PWS), superficial hemangiomas, poikiloderma of Civatte, facial telangiectasias, and rosacea.² PDL treatments utilize a wavelength of 585 or 595 nm to allow for deeper tissue penetration compared to the first-generation 577-nm wavelength emission. KTP laser therapy, also known as a frequency-doubled Nd:YAG laser, is a 532-nm

laser that is created by passing a 1,064-nm Nd:YAG laser through a KTP crystal. By doing so, the frequency is doubled and the wavelength cut in half. KTP lasers can be used to treat telangiectasias without eliciting purpura. Nd:YAG lasers have a lower affinity for hemoglobin, though due to their deeper penetration and lower affinity for melanin, this laser is a popular choice for treating darker skin types. IPL emits filtered polychromatic light with wavelength between 500 and 1,200 nm. IPL can be used for relatively nonspecific treatment of rosacea, PWS, hemangiomas, and poikiloderma of Civatte. In addition, IPL has been used in skin types I–III for photorejuvenation for chronic photodamage and hair removal.

VASCULAR CONDITIONS TREATED WITH LASERS

Port-wine stains

PWS, also known as capillary malformations, are almost always found at birth, and occur in about 0.3% of newborns.³ Clinically, they present as red patches that can occur anywhere on the body but are commonly found on the face following a V1–V3 dermatomal distribution. They persist throughout life and grow in proportion to the patient.⁴ As the patient ages, the lesions may darken to a deep purple hue, and overlying skin thickening or nodularity may occur.⁵ When located along the trigeminal distribution, they may be associated with other systemic symptoms such as those seen in the Sturge–Weber syndrome. More challenging areas to treat include the back and mid-cheek (V2 distribution) due to skin thickness, and extremities, due to slower healing times (Fig. 64-1).⁶



A



B

Figure 64-1. Port-wine stain treated with PDL test spots (A). Near complete treatment with multiple PDL sessions (B).

Laser treatment of PWS has been reported using the CO₂, argon, KTP, copper vapor, pulsed-dye, and Nd:Yag lasers. Historically, continuous wave argon and CO₂ lasers were used to treat PWS; however, these treatments often resulted in textural changes or scarring. PDL is currently the treatment of choice for PWS due to the low risk of scarring and acceptable complication rates, despite a relatively modest degree of total clearance, at approximately 15% to 20%.^{7,8} Multiple treatments are often required, and settings are adjusted based on the clinical response.

PWS lesions are often initially treated with a pulse duration of 0.45 ms with an increase in subsequent pulse durations as clinically appropriate. With the advent of coolant systems, higher fluences have been utilized. The majority of patients have significant improvement after multiple treatments. Treatment intervals are typically spaced from a few weeks to a few months apart, with improvement sometimes occurring several months after treatment. Clinical response is dependent on the treatment site as well as the skin type; PWS on the face and neck have an improved response rate when compared to extremities, though clinical response on the face is typically decreased for lesions along the V2 distribution. In addition, response rates are typically higher in skin types I and II. Anesthesia is not typically necessary for smaller lesions on adults, though topical or general anesthesia may be necessary depending on the lesion size or location and age of the patient (Fig. 64-2).



Figure 64-2. Port-wine stain of neck before (A) and after (B) treatment with several sessions of PDL therapy.

Poor therapeutic response may be due to inadequately damaged vessels, a potential product of variations in blood vessel sizes coupled with suboptimal laser parameters. The depth of penetration may be inadequate due to a shielding effect on the deeper vessels by more superficially located blood vessels that results in incomplete penetration to, and thus reduced treatment of, deeper blood vessels. Additional factors affecting response include whether the pulse duration exceeds the vessel response time. Second generation PDL devices incorporate longer pulse widths (0.45–1.5 ms), larger spot sizes (5, 7, 10 mm) with higher fluences (up to 11–12 J/cm²), and longer wavelengths (585–595 nm). These newer devices have resulted in an improved response rate with a higher percentage of vascular lesion reduction.³

Resistant PWS may be treated with Nd:Yag lasers;⁹ when treated at minimal purpuric settings, Nd:Yag lasers were shown to be as effective as PDL therapy, though higher fluences are associated with higher rates of scarring.¹⁰

More recent studies combining the 595-nm PDL and 1,064-nm Nd:Yag lasers have demonstrated efficacy in treating recalcitrant PWS, specifically those with associated hypertrophy.¹¹ Twenty-five children and adults with skin types I–IV were treated with PWS that were recalcitrant to greater than 10 PDL treatments. Patients were treated at 6-week intervals with a combined PDL and Nd:Yag laser (two laser heads) with sequential, timed pulses. Dual treatment showed improvement of PWS that were previously refractory to treatment with PDL only. Side effects included transient erythema, edema, and mild purpura.

Despite improved laser technology and cooling systems, PWS remain a challenge for complete clearance. The dynamic changes in growth and inherent variation based on anatomical location leave room for further investigation and improvement of current guidelines.

Port-Wine Stains

- Multiple treatments needed
- Adjust pulse width and fluence
- 1- to 3-month intervals

- Response affected by location on body
- Anesthesia optional based on patient population and lesion location

Telangiectasias

Telangiectasias are approximately 0.1 to 1.0 mm in diameter and are primarily found on the face, particularly on the nose, cheeks, and chin. They can be associated with systemic diseases such as liver disease, mastocytosis, or estrogen-secreting tumors, but are most frequently found in patients with chronic photodamage or rosacea. A number of different lasers have been used for treatment of telangiectasias, including PDL (purpuric and nonpurpuric settings), argon, krypton, pulsed KTP, and Nd:Yag lasers.

Purpuric settings consist of a single pass with shorter pulse durations (0.45, 1.5 ms) and higher fluences. The purpura can persist for days to weeks, necessitating patient counseling for potential down time, though more aggressive settings are associated with higher clearance rates per treatment session. Nonpurpuric settings require multiple passes with longer pulse durations (6 ms) and lower fluences. Nonpurpuric settings often result in erythema and occasional urticaria. However, due to the lack of purpura, there is essentially no down time. Nonpurpuric settings demonstrate variable response rates, often requiring more treatments than needed when purpuric settings are utilized. Nonpurpuric settings may be better suited for patients with recurrent flushing and central facial erythema ([Fig. 64-3](#)).

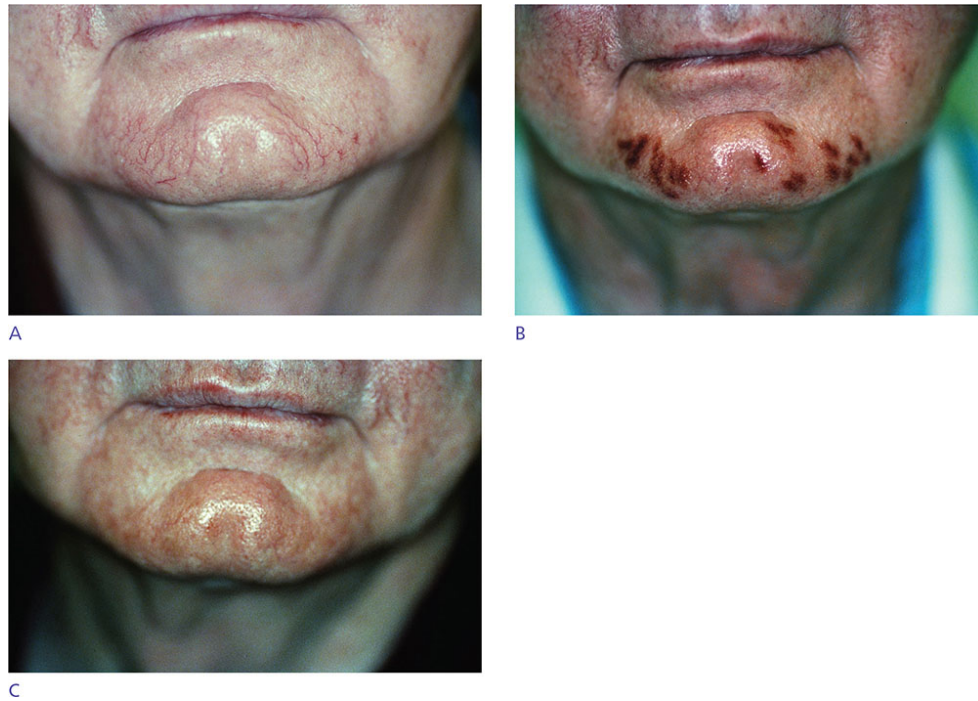


Figure 64-3. PDL treatment of telangiectasias with purpuric settings. Before treatment (A), purpura within a few days following treatment (B), and several weeks posttreatment (C).

Nd:Yag lasers may be used in darker skin types with darker and deeper facial vessels. Increased fluences are required due to decreased absorption at the 1,064 nm wavelength. One study showed that smaller, deep red vessels required higher energies and shorter pulse widths with Nd:Yag lasers, and saw moderate to significant improvement with two treatments with an endpoint of blanching.¹²

Rosacea and diffuse erythema have been successfully treated with PDL, IPL, and long-pulsed Nd:Yag (532-nm) laser. PDL lasers are typically set at longer pulse durations. Fluence and number of passes are dependent on the amount of chromophore and location. These settings are usually set at a lower starting point and then gradually increased with multiple treatments over 1- to 2-month intervals. PDL settings vary depending on the brand of machine used.

IPL's broad spectral range results in nonselective targeting of numerous chromophores, including oxyhemoglobin, thus improving vascular lesions. Treatment parameters include three to five treatments with 3- to 4-week intervals between treatments. Due to nonselective treatment, IPL is often utilized for full face treatment of redness reduction, improved skin texture,

and improvement of dyspigmentation. However, treatment results vary and patients may require numerous treatments to achieve meaningful clinical improvement.

Hemangiomas of infancy

Hemangiomas of infancy (HOI), or infantile hemangiomas, occur in 2.6% to 5% of infants, with a predilection for the head and neck.^{13,14} They most commonly occur in Caucasian infants, but are also seen in African-American, Hispanic, and Asian infants.¹⁵ They typically undergo a rapid growth phase, followed by a static phase, and then spontaneous involution. HOI are classified as superficial, deep, and mixed.¹⁶ Superficial hemangiomas are most common (50–60% of cases) and are often seen at birth, with a bright red appearance resembling a strawberry.¹⁷ HOI are further categorized into segmental or focal. Segmental hemangiomas resemble large plaques and have a greater risk of ulceration. Focal hemangiomas have a more nodular appearance.¹⁸ Small HOI may heal to resemble normal skin, but often involution results in hyper- or hypopigmentation, atrophy, or underlying fatty change.⁴

Telangiectasias, Rosacea, and Diffuse Erythema

- Purpuric settings result in decreased number of treatments but increased down time
- Nonpurpuric settings often result in need for several treatments but essentially no down time
- Start at lower fluence settings then slowly increase
- Multiple treatments are required at 1- to 2-month intervals

HOI treatment is primarily driven by location and size, as these factors often dictate the overall cosmetic outcome and degree of functional impairment. Areas that have greater risk for scarring include the nose, glabella, ears, and lips.⁴ Even small hemangiomas can potentially disfigure

the lip, given the vascular density of the vermillion border and the curvature of the philtrum. Similarly, mixed hemangiomas on the nasal tip can distort the underlying cartilage. In addition, both the nasal septum and the pinna of the ear are susceptible to hemangiomas ulceration.

PDL treatment for hemangiomas was first reported in 1989.¹⁹ Subsequent studies found that PDL was most useful for early treatment of superficial hemangiomas. This approach has also been reported for ulcerated lesions, though minimal response is seen with elevated lesions. Furthermore, there are reports of laser therapy inducing ulceration with subsequent scarring (Fig. 64-4).²⁰



Figure 64-4. PDL treatment of a port-wine stain on the neck. Before definitive treatment with only a few test spots treated (A), after treatment, demonstrating purpura (B), after purpura resolution, showing residual PWS presence (C), and after an additional round of therapy (D).

Hemangiomas of Infancy

- Treat as early as possible, every 2 to 4 weeks
- Can be helpful with ulcerated lesions

- No anesthesia usually required
- Medical treatment with beta blockers has become the standard of care for HOI

Indications for laser treatment include ulceration, residual telangiectasias after involution, and lesions with increased risk for scarring (especially those in the proliferative phase). Nd:Yag laser therapy has been used to treat hemangiomas; in a head-to-head study comparing Nd:Yag with PDL, PDL was slightly more effective, but both lasers had a low incidence of side effects.^{21,22} Successful treatment of HOI includes the use of appropriate fluences and pulse duration to minimize chances of scarring and pigmentary alterations. Patient selection is critical when determining laser treatment versus other medical treatments, such as beta blockers. HOI are typically treated as early as possible every 2 to 4 weeks, with lower fluences than PWS. Anesthesia is typically not required. Given the widespread use and high success rates with using topical and oral beta blockers, laser treatment for HOI is becoming less common.

Leg veins

Visible leg veins, composed of telangiectasias and venulectasias occur in approximately 80% of adults in the United States. Leg veins are caused by venous valvular incompetence resulting in increased hydrostatic pressure and vessel dilation. They most commonly occur on the legs due to gravitational dependency. Candidates for leg vein laser treatment include those with a prior history of minimal response to sclerotherapy, adverse reaction to sclerosing agents, telangiectatic matting, ankle veins, and needle phobias.²³

Both KTP and PDL have been used for the treatment of leg veins. These lasers are limited by their depth of penetration, resulting in significant inconsistency in treatment outcomes. Primary complications include hyper- and hypopigmentation, which has been reported to occur in 20% to 40% of patients.⁸ Broadband IPL has been used to treat leg veins with single, double, and triple pulsing with limited success, though cutoff filters may increase its efficacy. There is a relatively high incidence of dyspigmentation, possibly due to nonspecific chromophore selection. Longer wavelength lasers such as the long-pulsed Alexandrite and long-pulsed diode have been tried with

pulse durations ranging from 3 to 20 ms and 5 to 20 ms, respectively. There have been some encouraging reports,^{24,25} though the results have been inconsistent (Fig. 64-5).

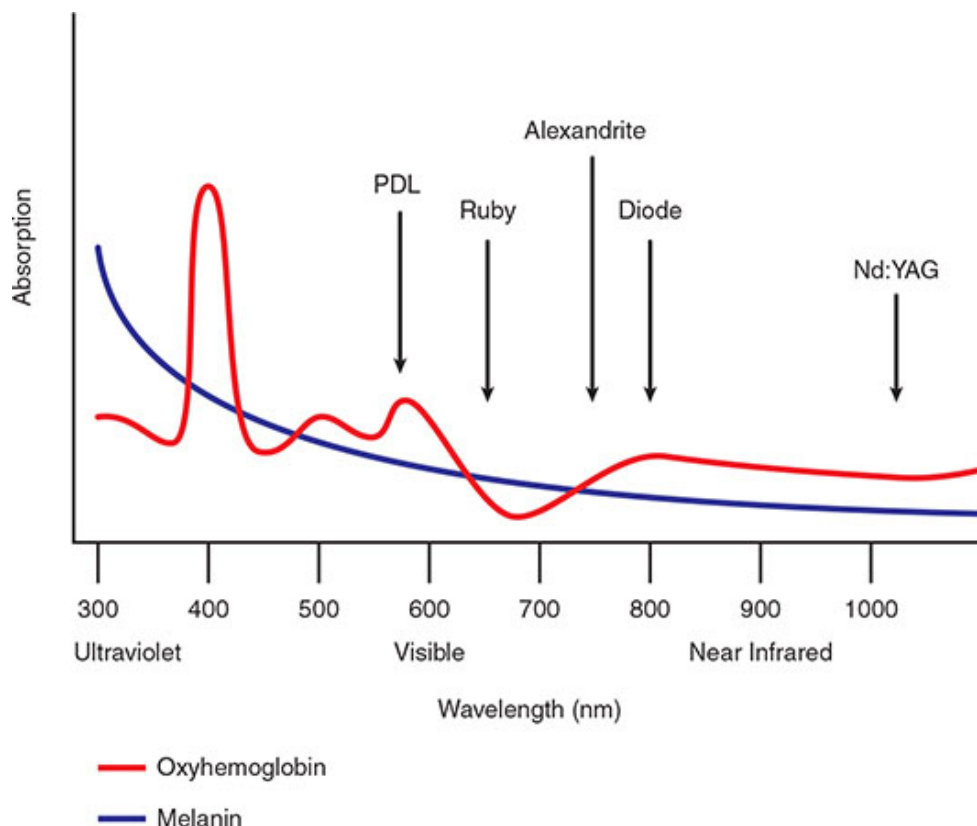


Figure 64-5. When choosing the appropriate laser for vascular lesions, the different absorption spectra for hemoglobin and melanin should be considered.

Long-pulsed Nd:Yag lasers with gel cooling have been used with fluences up to 150 J/cm², pulse duration 1 to 15 ms (single, double, triple pulsing can be applied), and a spot size of 6 mm. The treatments can be repeated at 6- to 8-week intervals. Caution must be taken with multiple passes, which can result in vessel rupture with subsequent hemosiderin deposition. The advantages of long-pulsed Nd:Yag lasers include adequate depth of penetration, minimal melanin absorption, and the ability to treat a full range of leg veins (up to 3 mm diameter and 5 mm depth) in darker and lighter skin types.

Laser approaches provide a noninvasive alternative to needle therapy or microphlebectomy. Complications may include scarring and pigment

alteration primarily due to hemosiderin deposition. A combination of lasers, phlebectomy, and sclerotherapy may be the best long-term approach for treating leg veins.²⁶ As a monotherapy, sclerotherapy remains the gold standard treatment for leg veins.

Leg Veins

- Adjacent pulses without overlap
- One to two passes
- Multiple passes can result in vessel rupture with subsequent hemosiderin deposition
- Six to eight weeks between treatments
- Limited utility with variable success means that this is a second-line therapy

CONCLUSIONS

Lasers are a mainstay of therapy for vascular lesions, and several types of lasers may be used for treating these conditions. While laser and light-based therapy remains the treatment of choice for PWS and telangiectasias, first-line treatment for HOI remains topical or systemic beta blockers and leg veins may be better treated with sclerotherapy, though combination approaches may hold significant promise.

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CHAPTER 65 Lasers for Pigmented Lesions and Tattoos

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Deborah S. Sarnoff



SUMMARY

- Lasers are frequently used to treat pigmented lesions and tattoos.
- Recent advances in picosecond lasers may improve both the efficacy and safety profile of these treatments.

- Depending on the depth of treatment, topical anesthesia or none at all is generally sufficient for most cases.

Beginner Tips



- Patients with a suntan or sunless tan should avoid laser treatments. The increased melanin on tanned skin acts as a competing chromophore and can increase the risk of adverse events.
- Extremely diligent sun protection is crucial after treatment of pigmented lesions such as lentigines, PIH, or melasma.
- Both UVA and UVB can trigger hyperpigmentation or hypopigmentation.

Expert Tips



- Tattoos often require multiple lasers to treat appropriately.
- Topical steroids may be considered after treatment of melasma or PIH to help prevent an inflammatory response that may worsen the pigmentation.
- Start with a lower fluence and increase with subsequent treatments.

Don't Forget!



- Extreme caution should be used prior to treating postinflammatory hyperpigmentation or melasma with lasers, as there is a risk of exacerbating the hyperpigmentation.
- Lasers should not be used routinely to treat nevi without a preceding biopsy, and generally should not be used to treat nevi in patients with a personal or family history of dysplastic nevi.

Pitfalls and Cautions



- Distinguishing a benign lentigo from lentigo maligna may be challenging. Any concerning features on examination or history should prompt a biopsy for a definitive diagnosis before laser therapy is performed.
- Allergic reactions are possible after treating tattoos, particularly red tattoos, due to breakdown and dispersal of the putative antigen.

Patient Education Points



- Realistic expectations are critical, particularly for tattoo removal.

- Some tattoos require as many as 20 rounds of treatment, and some tattoos will never clear completely.
- Postinflammatory hyperpigmentation and melasma may worsen after laser treatment.

Billing Pearls



- Almost all insurers in the United States exclude laser treatments from coverage.
- Patients may benefit from committing to a series of treatments, as this may allow significant cost savings.
- Pretreatment with occluded topical anesthesia can be started at home, and prescription plans may cover the cost of this medication.

CHAPTER 65 Lasers for Pigmented Lesions and Tattoos

INTRODUCTION

The principle of selective photothermolysis has revolutionized laser treatment for pigmented lesions and tattoos.¹ This principle describes the mechanism by which specific wavelengths of light are preferentially absorbed by a chromophore, leading to targeted destruction. There are three main components of selective photothermolysis. The laser wavelength must be preferentially absorbed by the target chromophore; the fluence, or energy per unit area, must be sufficient to destroy the target; and the pulse duration should be equal to or less than the thermal relaxation time (TRT) of the target.

FUNDAMENTAL CONSIDERATIONS

The three main chromophores in the skin are oxyhemoglobin, melanin, and water, and each preferentially absorbs different wavelengths of light. Ideally, a laser should emit a wavelength of light that is selectively absorbed by the target chromophore and that is not absorbed by the surrounding tissue. The absorption spectrum of melanin spans from 250 to 1,200 nm,² though the amount of absorption decreases as the wavelength increases (Fig. 65-1). Longer wavelengths penetrate deeper into the dermis, and are considered to

be safer in darker-skinned patients as they are associated with less epidermal damage.

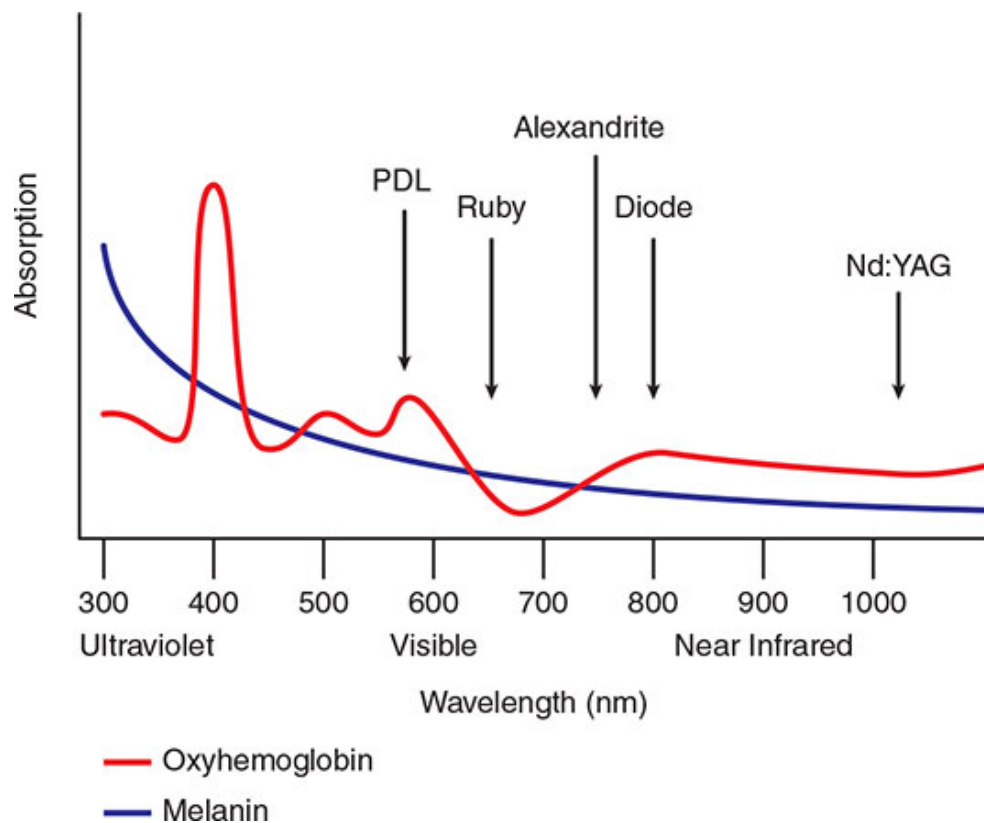


Figure 65-1. When choosing the appropriate laser for pigmented lesions, the different absorption spectra for hemoglobin and melanin should be considered.

The TRT is the amount of time required for the target to lose half of its heat. The TRT is related to the size of the target; overall, the smaller the chromophore, the shorter the TRT. If the pulse duration is equal to or less than the TRT of the target, the heat generated is confined to the target itself, and little energy diffuses into the nearby tissue, thus minimizing unwanted destruction. The TRT of melanosomes and tattoo particles are in the nanosecond or picosecond range.³ Therefore, Q-switched (QS) lasers that deliver pulse durations in the nanosecond range, and more recently, picosecond lasers, which deliver pulse durations in the picosecond range, have improved both the efficacy and safety of these treatments. By delivering high energy with very short pulse durations, the pigment is broken down into particles that are phagocytized by macrophages and easily eliminated from the body. The most common QS lasers are the 694-nm QS ruby, 755-nm QS

alexandrite, 1,064-nm QS Nd:YAG, and the 532-nm frequency-doubled QS Nd:YAG. Picosecond lasers include 532-nm, 755-nm, and 1,064-nm wavelengths. The photomechanical effects dominate over the photothermal effects, shattering the target into smaller particles and decreasing unwanted diffusion.⁴ With even shorter pulse durations than traditional QS lasers, picosecond lasers are able to use lower fluences for successful treatment.⁵ By treating with lower fluences, the risk of epidermal injury and dyspigmentation is minimized.

Long-pulsed ruby, alexandrite, or Nd:YAG lasers with pulse durations in the millisecond range have demonstrated efficacy for the treatment of superficial pigmented lesions. By delivering the energy over a longer duration, they are thought to gently heat the tissue and decrease the rate of adverse events.⁶

Fractional lasers, both ablative and nonablative, are gaining popularity as a treatment alternative for benign pigmented lesions. The ablative fractional lasers include the 10,600-nm carbon dioxide (CO₂) and the 2,940-nm erbium:yttrium aluminum garnet (Er:YAG). Nonablative fractional lasers include the 1,550-nm erbium-doped laser, the 1,565-nm fiber laser, and the 1,927-nm thulium laser. These lasers target water as opposed to melanin. The fractional lasers create microscopic injury zones, or microthermal zones (MTZ), in the epidermis and dermis. It has been suggested that the unwanted melanocytes and melanin are eliminated through these MTZ.⁷ Since only a portion of the epidermis and dermis is affected during each treatment, multiple treatments may be needed for satisfactory results.⁸

PATIENT SELECTION

A thorough medical history must be taken before initiation of treatment. Allergies, medical history, and medications should be reviewed. A history of treatment with gold therapy is a contraindication to treatment with QS lasers, as localized chrysiasis may be induced.⁹ For patients on isotretinoin, many recommend that treatment with lasers be deferred until after the medication is discontinued for 6 months, as there may be an increased risk of scar formation and delayed wound healing.^{10,11} However, recent publications have failed to show an increased rate of side effects when patients are

treated with lasers while on isotretinoin therapy.^{12–14} The possibility of scar development should be reviewed and appropriately documented in all patients, especially those with a history of keloid or hypertrophic scar formation. Antiviral prophylaxis may be necessary when treating areas with a history of herpes simplex outbreak.

Fitzpatrick skin type (FST) must be considered in patients undergoing laser therapy. The increased melanin in higher FSTs may absorb laser energy, leading to increased thermal injury to surrounding tissue and an ensuing increased risk of dyspigmentation and scarring. In addition, treatment efficacy decreases in patients with higher FST, as the increased pigment content of normal background skin competitively absorbs laser energy.¹⁵ Thus, a patient should not have a suntan or a sunless tan when receiving laser treatment. In order to reduce the risk of adverse events in dark-skinned patients, longer wavelengths, lower treatment fluences, and cooling devices may be used.¹⁶

Realistic patient expectations must be set prior to the initiation of therapy. Patients should be aware that multiple treatments will likely be necessary, and complete resolution is not always possible. Photographs should ideally be taken prior to treatment.

SAFETY AND PATIENT PREPARATION

Certain practices must be employed to ensure both the safety of the patient and the treating staff. Lasers used to treat tattoos and pigmented lesions are of the same wavelengths that can damage the retina. Therefore, all individuals in the room must wear goggles that protect against the specific wavelength being used. The patient should also be wearing protective eyewear. When treating an eyeliner tattoo or a pigmented lesion on the eyelid, a metal corneal shield must be placed under the patient's eyelid to protect the globe. Ophthalmic tetracaine is inserted onto the conjunctiva, and the concave aspect of the shield is coated with an ophthalmic lubricating ointment. While the patient is gazing up, the lower lid is retracted and the bottom aspect of the shield is inserted below the lower lid. The patient is then asked to gaze down and the top of the shield is placed below the upper eyelid. Reflective surfaces and all windows should be covered. A sign should be placed on the door to prevent accidental entry during treatment.

All make-up, creams, and topical anesthetics should be removed before treatment initiation, as they may alter the efficacy of the laser therapy. Chlorhexidine or alcohol may be used to clean the skin; if alcohol is used, it must be completely dry and residue free, as this may lead to an accidental fire. Caution should be taken that any flammable items are removed.

The need for anesthesia will vary depending on the location, size, and depth of the target. Treatment of superficial lesions with QS lasers often does not require anesthesia. For deeper lesions, sensitive areas, or fractional resurfacing lasers, topical anesthetics are generally sufficient, and should be applied for approximately 30 minutes under occlusion and completely removed prior to therapy. Local infiltrative anesthesia may be used for the treatment of dermal lesions, such as nevus of Ota, or tattoos.

Tattoos

As the percentage of the population with tattoos grows, the number of patients requesting the removal of unwanted tattoos has steadily increased.¹⁷ Pigment-specific nanosecond QS lasers and picosecond lasers are widely accepted as the gold standard for tattoo removal, though long-pulsed and ablative lasers have also been studied.

Nanosecond QS lasers

Traditional QS lasers provide a combination of a high peak power along with a nanosecond pulse duration allowing for effective destruction of the tattoo ink particle without destruction of the nearby tissue.¹⁸ Common QS lasers used for tattoo removal include the 694-nm ruby, 755-nm alexandrite, 1,064-nm Nd:YAG, frequency-doubled 532-nm Nd:YAG, and 532-nm KTP. The different wavelengths preferentially target certain colors ([Table 65-1](#)). If a tattoo is multi-colored, several lasers with different wavelengths must be used for the best results.¹⁹ Transient skin whitening is the desired treatment endpoint, and represents cavitation and the formation of gas bubbles in the epidermis from heating of the target.³ If whitening is not observed then the fluence is likely insufficient. If excessive fluence is used, breakdown of the epidermis or significant bleeding may occur.⁸ Lower fluences are recommended initially for dark, dense pigment as they have abundant target

chromophore, and the fluence may be increased as the tattoo fades.⁸ Typically, treatments are spaced 6 to 8 weeks apart, as more frequent treatments interfere with macrophage ink clearance and are associated with more adverse reactions.²⁰ Treatment risks include scarring, pigmentary alteration, and incomplete removal.

Table 65-1. Laser Options for Tattoo Removal Based on Tattoo Ink Color

Color	Pigment	Laser
Yellow	Cadmium sulfide	QS 510-nm pulsed-dye, QS KTP, QS Nd:YAG (frequency-doubled)
Red	Cinnabar Cadmium red	QS 510-nm pulsed-dye, QS KTP, QS Nd:YAG (frequency-doubled)
Green	Chromium oxide	QS ruby, QS alexandrite, picosecond alexandrite
Blue	Cobalt blue Azure	QS ruby, QS alexandrite, QS Nd:YAG, Picosecond alexandrite, picosecond Nd:YAG
Black	Carbon Iron oxide	QS ruby, QS alexandrite, QS Nd:YAG, picosecond alexandrite, picosecond Nd:YAG

Laser selection will vary depending on the color of the tattoo ink. The QS ruby, alexandrite, and Nd:YAG lasers (Fig. 65-2) have shown to be effective for the treatment of dark-blue and black tattoos.¹⁹ While the QS ruby and alexandrite may be effective in clearing dark ink, they are absorbed by melanin and are associated with unwanted pigmentary changes.^{21,22} The QS Nd:YAG has less absorption by epidermal melanin and keratinocytes, and is generally preferred for dark tattoos in darkly pigmented individuals.^{17,23} Both the QS ruby and alexandrite have also been shown to clear green tattoos.^{24,25} The frequency-doubled 532-nm Nd:YAG and the 532-nm KTP are often recommended for the treatment of yellow, orange, and red ink.^{22,26} Due to the risk of pigmentary alterations, especially in higher FSTs, a test spot treatment

may be advisable. The test spot should be examined approximately 1 month later for both dyspigmentation and efficacy.



Figure 65-2. Black tattoo (A) before and (B) after eight treatments with the QS 1,064-nm Nd:YAG laser. (Used with permission from D. Rainone, MD).

Despite the significant progress with QS lasers, tattoo removal can be frustrating, time-consuming, and costly. The number of required treatments varies greatly depending on the color, composition, density, depth, tattoo age, body location, and the quantity of tattoo ink present.¹⁷ For some tattoos, as many as 20 treatments may be necessary,²⁷ and satisfactory clearance may never be achieved.

In an attempt to optimize outcomes and enhance clearance, one study examined the combination of fractional resurfacing immediately following treatment with the QS ruby laser.²⁸ In this small series of three patients, they reported that both ablative and nonablative fractional resurfacing following QS laser of unwanted tattoos enhances tattoo clearance.²⁸ In another study, the use of daily 5% imiquimod cream as an adjunct to QS laser therapy was investigated, which demonstrated no improvement in efficacy but an increased rate of adverse events with the combination therapy.²⁹

In an effort to decrease the total number of treatment sessions with QS lasers, investigators have studied the feasibility of a multipass technique. Normally, immediately after treatment, cutaneous whitening is observed. This whitening is due to the formation of gas bubbles or vacuoles in the skin, limiting the penetration of the laser into the dermis. These intradermal

vacuoles resolve after 20 minutes and allow for repeat treatment. Kossida et al. demonstrated superior tattoo clearance with four passes with a QS alexandrite laser with 20 minutes between each pass (R20 method) compared to a single treatment with the QS alexandrite laser.³⁰ In order to eliminate the need to wait 20 minutes between each treatment, the “R0” method was created. By applying topical perfluorodecalin (PFD), the whitening reaction resolves almost immediately, allowing for repeat successive treatments. Reddy et al. recently reported the safety and efficacy of this method.³¹

Clinical research trials are currently examining the role of acoustic wave technology in combination with traditional Q-switched lasers. An acoustic wave device is applied to the tattoo after laser treatment to help disrupt the pigment containing macrophages and clear the intradermal vacuoles that are formed immediately after laser therapy. By rapidly dissipating the laser-induced vacuoles, multiple laser passes may be performed in a single treatment session.

Picosecond lasers

Picosecond lasers deliver pulse durations that are approximately 100 times shorter than traditional QS lasers, and are closer to the TRT of tattoo pigment. This ultrashort pulse width allows for more significant photomechanical effects and efficient break-up of the tattoo ink.⁵ More effective destruction of the target means that lower fluence is required,⁵ decreasing the rate of unwanted side effects. Currently, picosecond lasers are available in 532-nm, 755-nm, and 1,064-nm wavelengths (Figs. 65-3 to 65-5). Ross et al. compared 1,064-nm picosecond and nanosecond lasers for the treatment of black tattoos. With all other parameters constant, they demonstrated greater lightening with the picosecond pulses.³² One study by Brauer et al. reported at least 75% clearing of blue and/or green ink tattoos after one or two treatments with 755-nm picosecond laser.³³ More recently they reported clearing of yellow tattoos, which are notoriously difficult to treat, with a frequency- doubled Nd:YAG 532-nm picosecond laser (Fig. 65-6).³⁴



A



B

Figure 65-3. Multi-colored tattoo (A) before and (B) after six treatments with the 755-nm alexandrite picosecond laser. (Used with permission from R. Geronemus, MD).



A



B

Figure 65-4. Blue tattoo (A) before (B) after five treatments with the 755-nm alexandrite picosecond laser. (Used with permission from Clean Slate Laser).

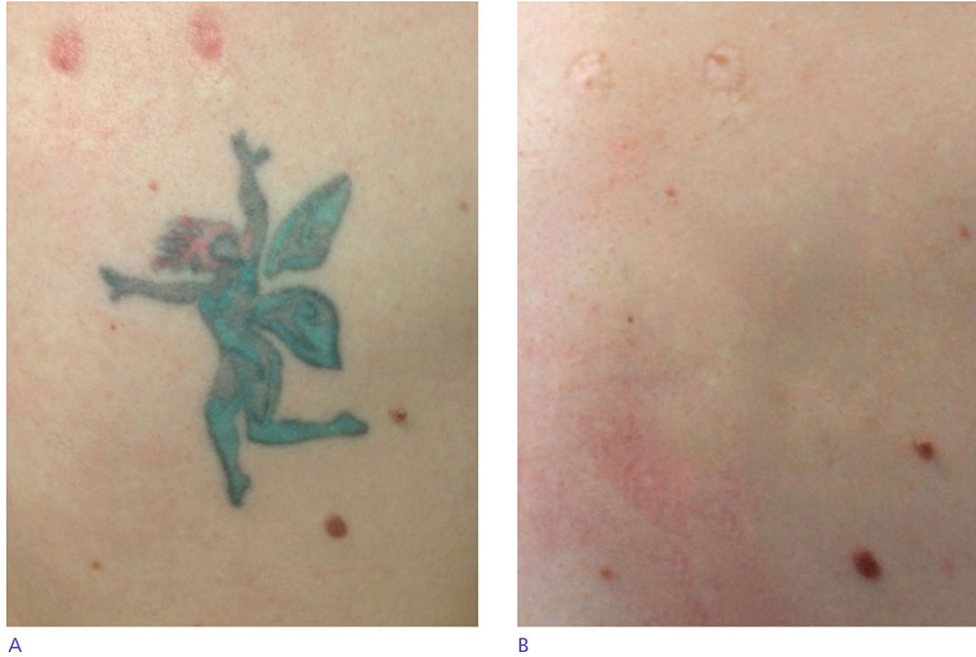


Figure 65-5. Green tattoo (A) before (B) after five treatments with the 755-nm alexandrite picosecond laser.



Figure 65-6. Red, orange, and yellow pigment treated with the 532-nm picosecond laser (A) before (B) after two treatments. (Used with permission from Cynosure, Inc).

Clinical considerations

For tattoo removal, several factors should be considered that will help estimate the number of treatments required. These include: FST, tattoo color,

location, amount of ink, layering of ink, and presence of scarring.³⁵ Lower FST, darker colors, and older tattoos tend to have a better treatment response.³⁶ Multi-colored tattoos, cover-up tattoos, and sleeve tattoos may be challenging to treat, and the use of several different lasers may be needed. Amateur tattoos tend to have less ink and are located in all layers of the epidermis. In contrast, professional tattoos place high concentrations of ink at the transition from papillary to reticular dermis.³⁷ Therefore amateur tattoos tend to require less treatments.³⁷

Caution must be taken when treating cosmetic tattoos with pink, tan, white, red, or brown pigment. Immediate and permanent darkening may occur after treatment with the QS lasers.^{38,39} The treatment of these cosmetic tattoos may reduce white ink composed of titanium dioxide (TiO_2 , Ti^{4+}) to blue Ti^{2+} or rust-colored ferric oxide (Fe_2O_3) to black ferrous oxide (FeO). If paradoxical darkening does occur, subsequent treatments with a resurfacing laser⁴⁰ or additional QS laser treatments targeting the darker color may be helpful.

Tattoo pigment is a foreign substance, and thus can cause an allergic or granulomatous response. The most common color to cause allergic reaction is red, as it may contain mercury-related compounds. Treatment of the ink with a laser may disperse the antigen, triggering a widespread allergic reaction.⁴¹ While safe treatment of red tattoo reactions with the QS 532-nm Nd:YAG in combination with topical steroids has been reported,⁴² many advise against the use of QS lasers in such cases and recommend treatment with the Er:YAG or CO_2 laser.^{43,44}

PIGMENTED LESIONS

Prior to treating pigmented lesions, it is imperative to ensure that the lesion has no atypical features. If there is any question regarding the diagnosis, or concern for melanocytic atypia, a biopsy must be performed prior to laser therapy. After ensuring that the lesion in question is benign, determining whether the pigment is located in the epidermis, dermal–epidermal junction, or dermis will help determine the appropriate laser wavelength. For melasma, which can have pigment in the epidermis, dermis, or both,

evaluation with a Wood lamp may be helpful in determining the pigment depth. If the pigment is located in the epidermis, it will be accentuated under Wood lamp examination, while dermal melasma will not demonstrate color accentuation. This distinction is very difficult to make in skin types V and VI.

As with tattoo removal, the desired treatment endpoint is transient skin whitening. For patients with FST IV–VI, it may be worthwhile to perform test spots to ensure the correct fluence is being used, as excessive fluences can lead to scarring, dyspigmentation, and burns.⁸ Many dermatologists will pretreat darker skin types with a bleaching agent such as hydroquinone 4% for 1 week prior to treatment, and a low to mid potency topical steroid for 3 to 4 days post-treatment.³⁶ The size and number of lesions must also be considered when estimating the number of treatments.

EPIDERMAL LESIONS

Commonly treated epidermal lesions include lentigines, ephelides, café-au-lait macules (CALMs), and nevus spilus. Anesthesia is usually not needed for the treatment of epidermal lesions. Any laser treatment that removes the epidermis will improve epidermal pigmented lesions. The ablative carbon dioxide and argon lasers were some of the earlier lasers used to treat epidermal pigment disorders, though due to their high rate of adverse events they have become less popular.⁴⁵ Pigment-specific nanosecond and picosecond QS lasers are generally considered the gold standard.

Lentigines and ephelides

Since the pigment is located superficially, lasers with short wavelengths that have a high absorption by melanin and do not penetrate deeply are effective. Although studies for ephelides are limited, the most commonly used lasers for lentigines and ephelides are the QS frequency-doubled Nd:YAG,⁴⁶ QS ruby,⁴⁷ and the QS alexandrite (Fig. 65-7).^{48,49} The long-pulsed alexandrite laser has demonstrated efficacy and safety for the treatment of dark lentigines.⁵⁰ Usually, two to three treatments can completely clear lentigines, and there is a low rate of recurrence, though recurrences tend to be more common with ephelides.⁴⁹

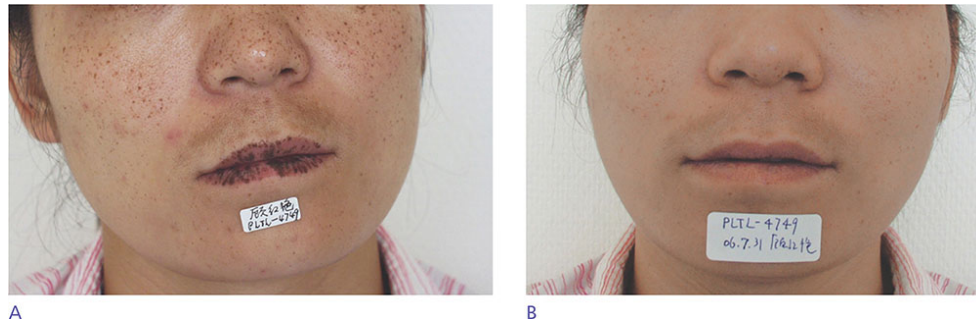


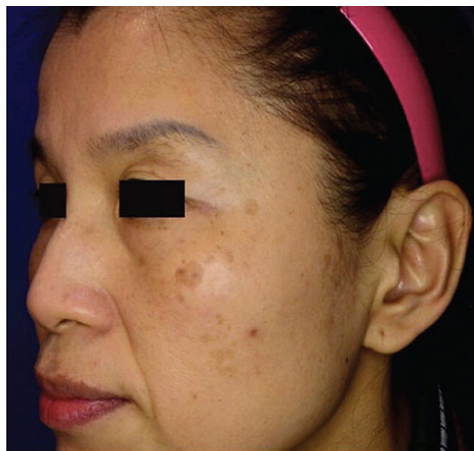
Figure 65-7. Ephelides (A) before (B) after five treatments with the QS 755-nm alexandrite laser. (Used with permission from L. Zhong, MD).

For widespread lesions or diffuse photodamage, fractional ablative, or nonablative lasers, and intense pulsed light (IPL) can be effective alternatives. Studies have reported improvement in photodamage and dyspigmentation with the 1,550-nm erbium-doped fractional device.^{51,52} For the treatment of lentigines, a 2010 consensus panel recommended three to five treatments at monthly intervals with fluences between 10 and 20 mJ and treatment levels from 7 to 11 for FST I–III and 4 to 7 for higher FSTs with the 1,550-nm erbium-doped fractional device.⁵³ More recently the 1,927-nm thulium fiber fractionated laser has demonstrated efficacy for the treatment of photopigmentation and lentigines.^{54,55} The 1,927-nm wavelength has a higher affinity for water than the 1,550-nm erbium-doped fiber laser, and therefore more effectively targets epidermal processes.⁵⁶ IPL uses broadband visible light emitted from a noncoherent, nonlaser, filtered flashlamp, and has been shown to improve superficial pigmented lesions, with a low rate of postinflammatory hyperpigmentation (PIH) (Fig. 65-8).^{57,58}



Figure 65-8. Treatment of lentigines with the IPL laser. (Used with permission from Robert and Margaret Weiss, MD).

Although large-scale studies are needed, picosecond lasers may represent alternative treatment options for lentigines and pigmentary alterations from photodamage. More recently, a specialized optical hand attachment composed of approximately 120 diffractive lenses that release high levels of energy to focused areas has been developed for the 755-nm picosecond laser. Less than 10% of the skin is exposed to a high fluence while the surrounding skin is treated with lower fluence. Treatment with a 755-nm picosecond laser with the focus lens array has demonstrated efficacy for photoinduced dyspigmentation (Figs. 65-9 and 65-10).⁵⁹



A



B

Figure 65-9. Lentigines (A) before (B) after five treatments with the 755-nm picosecond laser with the focus array. (Used with permission from S. Shin, MD).



Figure 65-10. Photoaging (A) before (B) after one treatment (C) 6 months after three treatments with the 755-nm picosecond laser with the focus array. (Used with permission from C. Cheng, MD).

Café-au-lait macules and nevus spilus

Before initiating laser treatment of CALMs, if numerous lesions are present a thorough history must be taken to rule out neurofibromatosis. Treatment of CALMs may be challenging, as multiple treatments may be required, and incomplete removal and recurrence are common. QS lasers, including the ruby, alexandrite, and Nd:YAG have successfully treated CALMs and nevus spilus.⁶⁰⁻⁶² While additional larger studies need to be performed, improvement of CALMs with the 755-nm picosecond laser has been demonstrated (Fig. 65-11).^{4,63}



Figure 65-11. Café-au-lait macule (A) before (B) after two treatments with the 755-nm picosecond laser. (Used with permission from M. Taylor, MD).

Mixed dermal–epidermal lesions

Pigment can be found in both the epidermis and the dermis in PIH, melasma, Becker's nevus (BN), and melanocytic nevi.

Postinflammatory hyperpigmentation

PIH is a result of hemosiderin or melanin deposition in the skin after epidermal or dermal injury or inflammation, and is more common in darker skin types. Although epidermal melanin tends to be more responsive to 532-nm than 1,064-nm wavelengths, there is a higher risk of hyperpigmentation and worsening of PIH with shorter wavelengths, particularly in darker-skinned patients. Studies have reported improvement of PIH with the 1,064-nm QS Nd:YAG laser with low fluence in patients with higher FSTs.^{64,65}

Nonablative fractional lasers have some efficacy in the treatment of PIH.^{66,67} However, care must be taken, as laser treatment of PIH may exacerbate the hyperpigmentation. Many dermatologists do not recommend the use of lasers for PIH at this time. Although additional studies must be performed,

picosecond technology may be employed for PIH due to its favorable side-effect profile and low rates of dyspigmentation.

Melasma

Melasma, which can be epidermal, dermal, or mixed, can be extremely challenging to treat. Although controversial, factors that have been suggested to play a role in the pathogenesis of melasma include hormonal therapy, pregnancy, ultraviolet light radiation, irritating cosmetics, phototoxic medications, and genetic factors.⁶⁸ The response rate is inconsistent, and recurrence is very common. Like PIH, care must be taken, as any associated inflammation can trigger melanocytic activity and worsen the dyschromia. First-line treatments for melasma include broad-spectrum sunscreens and bleaching agents. Patients must be counseled on the use of sunscreen at all times and that even minimal sun exposure can trigger melasma. Lightening agents such as hydroquinone, topical retinoids, kojic acid, azelaic acid, and Kligman's formula (5% hydroquinone, 0.1% tretinoin, 0.1% dexamethasone) should be attempted prior to laser therapy and as maintenance. Chemical peels with glycolic acid, lactic acid, and trichloroacetic acid may be helpful, though caution must be taken to prevent inflammation and PIH especially in darker skin types. While improvement with the QS ruby, QS alexandrite, QS Nd:YAG, 1,550-nm erbium-doped fractional laser, CO₂ fractional laser and IPL have been shown, worsening and recurrence has been a challenge.^{69–74} Repeated treatments with the 1,064-nm Q-switched, Nd:YAG laser with a low fluence has become a popular method to treat melasma. Kauvar et al. treated 27 patients at 4-week intervals with microdermabrasion followed by QS Nd:YAG at 1.6 to 2.0 J/cm² and topical hydroquinone, and reported continued improvement in melasma after 1 year.⁷⁵ Multiple treatments are often necessary, there is high rate of recurrence⁷⁶ and guttate hypopigmentation has been reported with this technique.⁷⁷ Improvement in melasma has also been seen with the 755-nm picosecond laser with the focus lens array (Fig. 65-12). The 1,927-nm thulium fiber laser, with a high absorption coefficient for water, targets epidermal processes; it has had some efficacy with the treatment of melasma, and a low side-effect profile.^{54,78,79}

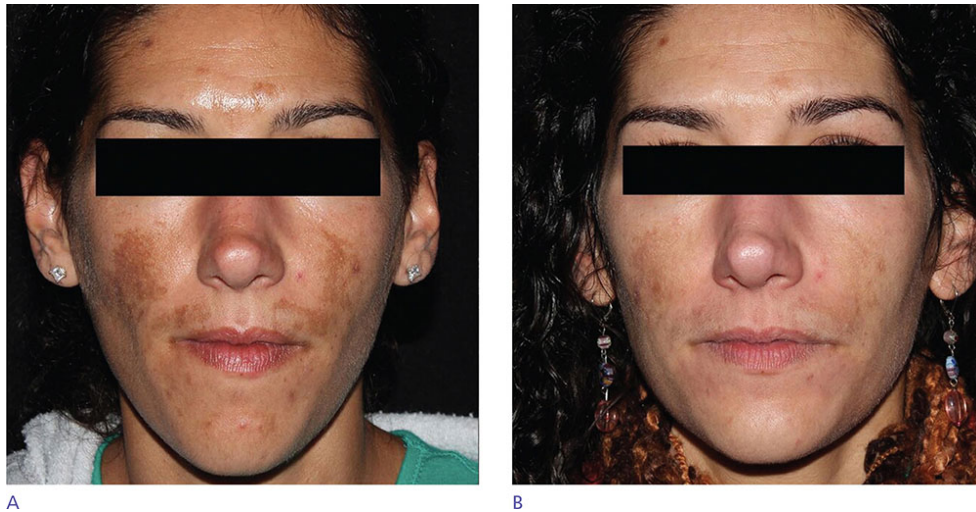


Figure 65-12. Melasma (A) before (B) after four treatments with the 755-nm alexandrite picosecond laser with the focus array. (Used with permission from L. Espinoza, MD).

Becker's nevus

A BN is a benign hamartoma that presents most commonly in adolescence as a brown patch with overlying dark hair. Laser treatment of BN is variable and often disappointing.⁸⁰ Improvement in pigmentation has been reported with the QS ruby and QS Nd:YAG. A comparative study showed the QS ruby to be superior to the QS 1,064-nm Nd:YAG.⁶⁰ The QS lasers do not decrease hair density, and recurrence of pigment is frequent. Ablative lasers such as the Er:YAG and CO₂ laser,^{81,82} and nonablative 1,550-nm fractional erbium-doped fiber laser have reported improvement in pigmentation, but no effect on hypertrichosis.⁸³ Terminal hair reduction as well as pigment lightening has been demonstrated with long-pulsed ruby and alexandrite lasers.^{84,85}

Melanocytic nevi

Surgical excision is the standard of care for removal of benign melanocytic nevi. There are select cases in which a scar resulting from the excision of a benign nevus may be undesirable or near a vital structure, and therefore laser therapy may be considered. A biopsy should be considered prior to laser therapy to ensure the benign nature of a nevus, and those with a personal or family history of melanoma should not have their nevi treated with laser

therapy. There is a theoretical concern that laser irradiation has the ability to promote malignant change, though this is controversial.

Junctional melanocytic nevi that are present in the epidermis and superficial dermis have been treated successfully with the QS ruby laser, QS alexandrite laser, and frequency-doubled QS Nd:YAG laser.⁴⁵ Congenital nevi often have melanocytes in the deep dermis and surrounding adnexae, and do not respond consistently to QS lasers. Combining treatment with both the QS ruby laser and normal mode ruby laser has produced favorable results.⁸⁶ However, multiple treatments are often necessary, and the patient must be aware that dermal nevus cells often persist, so life-long follow-up is necessary.⁸⁷ Ablative resurfacing lasers, such as the Er:YAG and the CO₂ may improve pigmentation,^{88,89} though scarring may develop.⁸⁸

Dermal lesions

Dermal lesions, such as nevus of Ota, nevus of Ito, Hori's nevus, and congenital dermal melanocytosis often require treatment with lasers with longer wavelengths that have the ability to penetrate deeply into the dermis. A topical or intralesional anesthetic may be helpful. Dermal lesions may slowly improve over months as phagocytosis of the dermal pigment and gradual clearance occurs.⁸

Nevus of Ota, Ito, and Hori

QS lasers, including the QS Nd:YAG, QS alexandrite, and the QS ruby have been used to treat a nevus of Ota, Ito, and Hori's nevus (Figs. 65-13 and 65-14).^{48,90-92} While QS lasers are helpful, adverse events such as permanent hypopigmentation and textural changes can occur, and many lesions do not completely respond.⁹³ The picosecond alexandrite laser has recently been shown to be an effective therapy for the nevus of Ota, and is associated with a lower rate of PIH (Fig. 65-15).^{4,63}

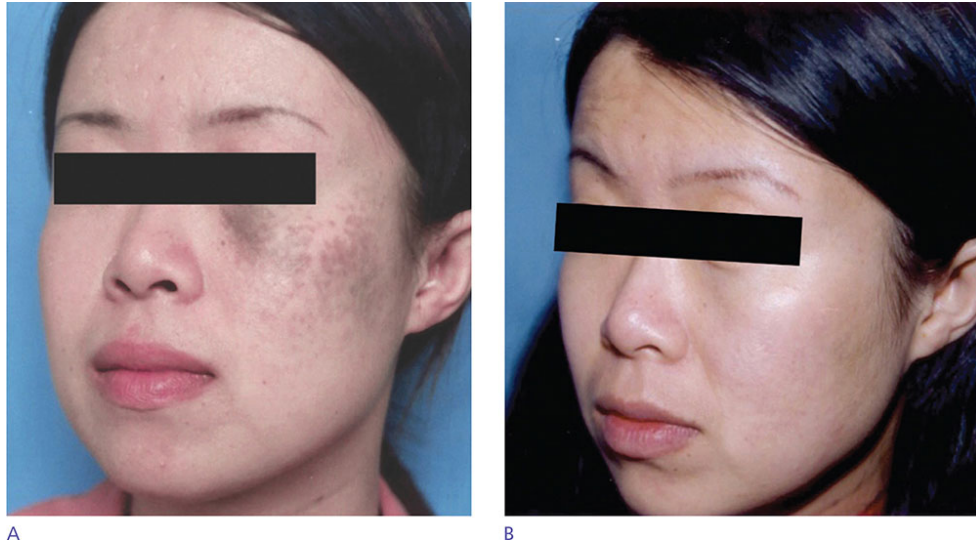


Figure 65-13. Nevus of Ota (A) before (B) after seven treatments with the QS 755-nm alexandrite laser. (Used with permission from H. Wang, MD).

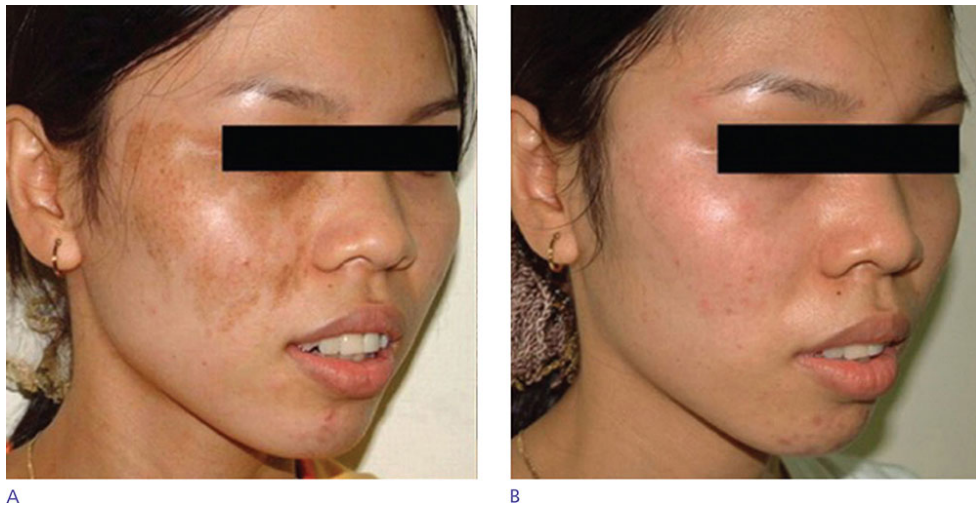


Figure 65-14. Hori's nevus (A) before (B) after five treatments with the QS 1,064-nm Nd:YAG laser. (Used with permission from T. Tu, MD).



Figure 65-15. Nevus of Ota (A) before (B) after one treatment with the 755-nm alexandrite picosecond laser. (Used with permission from H. Chan, MD).

Postoperative care

After treatment with QS lasers, the treated site becomes darker and often develops a crust that lasts approximately 1 to 3 weeks. The areas should be cleansed gently daily with a mild soap and water, and an occlusive ointment should be applied regularly. Strict sun avoidance must be practiced.

Immediate posttreatment pain is common, and is often alleviated by ice packs and cold compresses. Urticaria may also be seen after treatment. Vesicles may develop after treatment of tattoos with QS lasers, though this is generally not seen after treatment of epidermal or dermal lesions. Transient erythema, edema, and pain may be seen after treatment with picosecond lasers, and should resolve within 1 week.

In patients treated with fractional lasers or IPL, erythema, edema, crusting, and peeling are expected. Use of sunscreens and moisturizers is usually sufficient. A sunburned sensation may develop, which can usually be controlled with cool compresses. As with QS lasers, initial darkening of pigmented lesions may occur.

CONCLUSIONS

As laser technology evolves and lasers become more selective, the removal of unwanted tattoos and pigmented lesions is becoming increasingly common. The dermatologic surgeon must be aware of nuances in laser therapy to ensure safe and effective treatments. Appropriate patient selection and strict adherence to protocols are crucial. In addition, correct diagnosis of pigmented lesions is essential prior to initiation of laser therapy. While the field has dramatically expanded, further investigation optimizing these technologies and guidelines is warranted.

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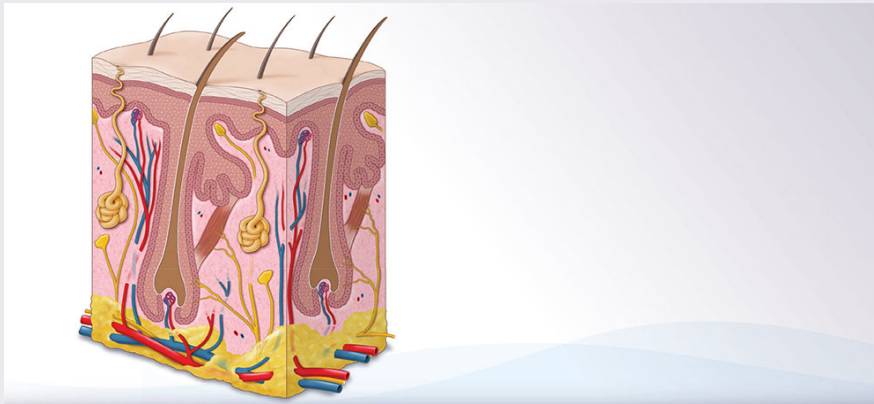
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CHAPTER 66 Laser- and Light-Based Approaches to Hair Removal

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SUMMARY

- Hair removal is one of the most common aesthetic procedures performed in the United States, and the number of procedures performed each year continues to increase.

- A full treatment course for hair reduction typically consists of six to eight treatment sessions, commonly spaced 3 to 6 weeks apart.

Beginner Pearls



- Light-based therapies shown to be effective for LHR include ruby lasers, alexandrite lasers, diode lasers, Nd:YAG lasers, and intense pulsed light (IPL).
- The long-pulsed Nd:YAG is the most appropriate laser in darker-skinned patients because the longer wavelength and greater depth of penetration reduces the risk of epidermal injury when combined with appropriate epidermal cooling measures. IPL can also be used for hair removal in lighter-skinned patients (skin types I–III) depending on the filter used.
- The desired clinical endpoint for LHR is perifollicular erythema and edema.

Expert Pearls



- The hair should be freshly shaved, so that it is <1 mm in length, and so that exposed hair shafts do not lead to inadvertent epidermal burns.

- A dark-colored pen has an absorption spectrum similar to melanin, and can cause inadvertent burns and scarring, so white pencil is best used if marking the treatment site.

Don't Forget!



- Physicians treating a patient with a history of recurrent herpes simplex virus (HSV) infections in the area of treatment should consider providing a course of anti-HSV medication such as valacyclovir.
- With IPL, posttreatment effects (perifollicular erythema) are not always apparent.

Pitfalls and Cautions



- Signs of tissue necrosis include immediate or delayed blistering, and/or graying or blackening of the skin. If tissue necrosis occurs, adjustment of the treatment parameters to increase the pulse duration and decrease the fluence should be strongly considered.

- Additional warning endpoints include a positive Nikolsky sign indicating epidermal necrosis; second- or third-degree “stamping burns,” indicating inadequate cooling, possibly from skin or charred hair residue on the skin contact window; crescent-shaped burns suggesting misalignment of the laser or cryogen cooling spray; or charring caused by tissue carbonization and burning.

Patient Education Points



- Multiple treatments will be needed to attain significant clinical improvement. It is important to review this with patients prior to initiating therapy so that they understand that a single treatment will likely yield only minimal improvement.
- While some patients (and laser systems) do not regularly need topical local anesthesia prior to treatment, this is variable, and many patients may benefit from anesthetics, particularly in sensitive locations.

Billing Pearls



- Almost all insurers in the United States exclude laser treatments from coverage.
- Patients may benefit from committing to a series of treatments, as this may allow significant cost savings.

- Pretreatment with occluded topical anesthesia can be started at home, and prescription plans may cover the cost of this medication.

CHAPTER 66 Laser- and Light-Based Approaches to Hair Removal

INTRODUCTION

Hair removal is one of the most common aesthetic procedures performed in the United States, and the number of procedures performed each year continues to increase. Hair removal is most commonly performed to reduce cosmetically unwanted hair, though it is occasionally performed for medical purposes to treat hirsutism.

Laser-, light-, and energy-based devices may all be used to remove hair. Laser hair reduction (LHR) was introduced in 1996.¹ The FDA terms this removal of hair as “hair reduction” to help guide patient expectations and to accurately portray outcomes, as the decrease in hair may not be permanent, and all of the hairs in a treated area may not be fully removed even after several treatments. A full treatment course for hair reduction typically consists of six to eight treatment sessions, commonly spaced 3 to 6 weeks apart. The term *laser hair reduction* is also used as hair may spontaneously regrow (often several years after completion of treatment with satisfactory hair reduction), and women who become pregnant and patients on hormonal therapy may experience a regrowth of previously successfully removed hair.

Hair reduction is performed in a variety of medical environments, and sometimes in so-called medi-spa environments as well. As medical practice laws vary by state, depending on the location, hair reduction may be

performed by a physician, or—if allowed by state law—the procedure may be delegated to a member of the medical treatment team and performed by a nurse clinician, physician assistant, nurse, or medical assistant. In certain jurisdictions, based on local laws, LHR can be performed outside of medical offices with or without direct or indirect medical physician supervision or oversight.

Background

LHR functions based on the theory of selective photothermolysis. Dr. R. R. Anderson and Dr. J. Parrish pioneered the concept of the theory of selective photothermolysis in 1983,² which specified that specific wavelengths of light and pulse durations can be selectively used to target different chromophores, which are color- or water-based structures in the skin. Effective LHR treatments use permutations of the following key parameters: (a) wavelengths that selectively target the hair follicle as a chromophore, (b) enough fluence (energy) to lead to destruction, and (c) a pulse duration short enough to confine energy to the hair follicle to selectively destroy the hair follicle without damaging the surrounding tissue (based on the thermal relaxation time). A key consideration when performing hair reduction is sparing damage to the surrounding tissue. Selective treatment of the hair follicle and sparing of injury to the surrounding skin are achieved based upon the *thermal relaxation time* of the hair follicle, which is based on the diameter of the hair follicle. To account for the width of the hair follicle and to safely confine the treatment laser energy within the hair follicle, the duration of each laser pulse is spread over milliseconds (ms). The typical pulse duration range is from 30 to 50 ms.

History and evolution of technology

LHR was introduced in 1996. Over the years, LHR technology has expanded to include lasers that were pioneered to be safely used in skin of color with the advent of the neodymium-doped yttrium aluminum garnet (Nd:YAG) 1064-nm long-pulsed laser. Diode lasers allow for the largest treatment spot sizes on the commercial market, enabling the fastest treatment of large surface areas. In recent years, other nonlaser energy-based devices have

been found to reduce hair, such as radiofrequency and microwave technology.

Mechanism of action

The mechanism of action associated with LHR is based upon the theory of selective photothermolysis, wherein the laser wavelength used for treatment can selectively target a chromophore in the skin—in this case melanin in the hair follicle—to heat the hair follicle and cause selective destruction of the follicle. Clinically, hair reduction works best with dark hair (black) on a background of fair skin. White hair is a challenge to remove, as the hairs and hair follicle lack sufficient melanin for the laser to selectively target the hair follicle for destruction. Radiofrequency and microwave technology work to remove hair follicles by bulk heating the dermis to a temperature that is hot enough to induce hair follicle death and ultimate reduction in hair.

LASER HAIR REDUCTION METHODS

Lasers used for LHR utilize wavelengths of 600 to 1,200 nm in the red and near-infrared portion of the electromagnetic spectrum to target melanin as their primary chromophore. Light-based therapies shown to be effective for LHR include ruby lasers, alexandrite lasers, diode lasers, Nd:YAG lasers, and intense pulsed light (IPL).³ The pulse durations used depend on the thermal relaxation time of a hair follicle, and typically range from 30 to 50 ms. In certain circumstances, a wider range of pulse durations is used, which range from 10 to 100 ms, and pulse durations of up to 1,000 ms have been used, though they are uncommon in routine clinical practice.⁴ There are myriad potential indications for LHR, including aesthetic reasons, hirsutism, inflammatory conditions (pilonidal sinus disease, hidradenitis suppurativa, pseudofolliculitis barbae), congenital conditions, aberrant hair growth from surgical intervention, reduction of hair in those undergoing hormonal therapy, and treatment of scrotal skin prior to gender reassignment vaginoplasty.^{5,6}

The choice of laser for hair removal depends mainly on skin type. Long-pulsed ruby lasers were the first to be used for laser hair removal, but they have generally fallen out of favor due to potential energy absorption by epidermal melanin, and are no longer marketed in the United States for hair

removal.⁷ The long-pulsed ruby laser is best used in patients who are fair-skinned, Fitzpatrick skin types I to III, whereas classic alexandrite and diode lasers can be used in people up to skin type IV. The long-pulsed Nd:YAG is the most appropriate laser in darker-skinned patients because the longer wavelength and greater depth of penetration reduce the risk of epidermal injury when combined with appropriate epidermal cooling measures. IPL can also be used for hair removal in lighter-skinned patients (skin types I–III) depending on the filter used.³

PATIENT SELECTION AND SAFETY

Clinicians should employ safety precautions when using lasers and light-based devices. Laser treatment rooms should have opaque windows and warning signs to indicate when the laser is in use. The patient and all personnel involved in the procedure should wear wavelength-specific eye protection. Laser hair removal within the orbital rim should be avoided due to risk of pinhole vision defects.⁸ Plume evacuator use may be utilized, as the plume may contain infectious viral particles and contains carcinogenic matter.^{9,10}

Because the target chromophore of LHR is melanin, the ideal patient for the LHR procedure is someone with light skin and thick, dark hair. Patients with darker skin tend to have a decreased contrast between the color of the hair and the skin, leading to a higher risk of inadvertent energy absorption in the surrounding skin. For this reason, a laser test spot in an inconspicuous area may be employed. It is also helpful to perform a laser test spot in the area being treated, as the skin response to laser therapy may vary and differ in different anatomical sites.

Initial evaluation of a patient should include a detailed medical history, including screening for endocrinologic and menstrual irregularities that may signal a treatable medical cause of hirsutism.¹ Physicians should evaluate patients with sudden-onset lanugo-type hypertrichosis for a paraneoplastic syndrome or eating disorders.^{11–13} They should also screen for potential contraindications or relative contraindications of treatment, including photosensitivity, photosensitizing medications, daily use or recent use (within 1 week pre or post) of facial cleansing brushes, koebnerizing conditions such

as psoriasis and vitiligo,¹⁴ recently tanned skin, history of poor wound healing or increased risk of skin infections, and a history of keloidal scars.

Physicians treating a patient with a history of recurrent herpes simplex virus (HSV) infections in the area of treatment should consider providing a course of anti-HSV medication such as valacyclovir or acyclovir. There is evidence for the safety of LHR during isotretinoin therapy,^{15–18} suggesting that the prior recommendation against LHR for 6 to 12 months after isotretinoin treatment should be reconsidered.

PREPARATION

Prior to initiation of the LHR procedure, the physician should discuss the risks, benefits, alternatives, potential side effects, and expected results of the LHR procedure. A discussion of expected results should include mention that hair reduction may not be permanent, the potential for poorer response in thinner- or lighter-colored hairs, potential for no response for red, gray, or white hairs, and the need for multiple treatments, often in a range of six to eight treatments. Alternatives to LHR should be reviewed, including trimming, shaving, bleaching, waxing, tweezing, threading, use of chemical depilatory agents, electrolysis, and thermolysis.¹⁹

Clinicians should familiarize themselves with the appearance of both therapeutic and warning endpoints to appropriately tailor the laser settings to achieve clinical efficacy while minimizing adverse effects.^{20,21} These visual signs are evidence of early tissue reactions that are either desirable, such as perifollicular erythema and edema, or undesirable, such as epidermal necrosis. The desired clinical endpoint for LHR is perifollicular erythema and edema.²¹ Signs of tissue necrosis include immediate or delayed blistering, and/or graying or blackening of the skin. If tissue necrosis occurs, adjustment of the treatment parameters to increase the pulse duration and decrease the fluence should be strongly considered. Additionally, reassessment of the treatment device is recommended to ensure compatibility with the patient's skin type. It is also important to exercise medical caution in treating patients with recently tanned skin. Additional warning endpoints for LHR include a positive Nikolsky sign indicating epidermal necrosis, second- or third-degree "stamping burns," indicating inadequate cooling, possibly from skin or charred hair residue on the skin contact window, crescent-

shaped burns suggesting misalignment of the laser or cryogen cooling spray, or charring caused by tissue carbonization and burning.²⁰

The first step of laser hair removal is to turn on and allow the selected device to warm up. The patient's skin should be prepared by cleaning with soap and water, and degreasing the relevant areas with alcohol wipes or a similar compound. The skin should be free of personal care products such as deodorant, makeup, lotions, or self-tanner. The hair should be freshly shaved, so that it is <1 mm in length, and so that exposed hair shafts do not lead to inadvertent epidermal burns. Since much of the targeted melanin is in the hair shaft, patients should also avoid procedures that remove the hair shaft such as waxing, plucking, or electrolysis for at least 6 weeks. Depending on the type of laser used, a layer of either refrigerated or room-temperature transparent, water-based gel may be applied to act as a heat sink for epidermal protection.²²

The use of topical anesthesia is not universally required for laser hair removal, but may be indicated depending on patient tolerance of discomfort and the anatomic site.²³ Sensitive regions of the body such as the upper lip or groin area may benefit from 30-minute to 1-hour incubation of a topical anesthetic like lidocaine, prilocaine, betacaine, or tetracaine.^{1,24} Forced cooled air can be soothing to the patient during and after the procedure.

The laser and cooling device should be tested to make sure the system is working appropriately. The clinician should choose appropriate settings based on the patient's prior treatments and skin type. Some clinicians recommend marking the site, but it is important to remember that a dark-colored pen has an absorption spectrum similar to melanin, and can cause inadvertent burns and scarring, so white pencil is best used if marking the treatment site.²⁵ Many others have not found a need to mark the treatment site.

TYPES OF TREATMENTS

Alexandrite laser

Introduction

Finkel et al. first used the long-pulsed alexandrite laser for laser hair removal in 1997.²² This laser has a wavelength of 755 nm, which allows for deep penetration into the dermis, with a relatively low affinity for hemoglobin.²² This laser has several convenient features that explain why it is one of the most widely used lasers for LHR. It has a flexible optical fiber arm that allows maneuverability across different body sites. These lasers are generally compact machines that can fit into smaller rooms as long as there is adequate ventilation, and the large spot sizes (up to 18 mm) also make it easier to treat large surface areas.²⁶ The cooling systems for these lasers vary depending on the model, and include cold air cooling, contact cooling, and dynamic cooling.⁷ Long-term efficacy for LHR varies based on number of treatments, and ranges from 4% hair reduction at 6 months after one treatment²⁷ to 40% to 74% hair reduction at 6 months after three treatments^{28,29} to 78% to 85% hair reduction at 1 year after four to five treatments.^{30,31}

Several studies comparing the alexandrite laser to other lasers and light devices have found alexandrite to be noninferior to diode,^{29,30,32,33} IPL,^{34–36} and Nd:YAG lasers.³² Another study comparing the efficacy of alexandrite versus a combination of alexandrite and Nd:YAG found no additional benefit to Nd:YAG over alexandrite alone.³² A study of 18 patients found no significant difference in efficacy or side effects between long-pulsed and short-pulsed alexandrite laser, though short-pulsed alexandrite procedure was about five times faster than the long pulse.³⁷ Marayiannis found that, in a study with 389 patients comparing long-pulsed alexandrite, short-pulsed alexandrite, and IPL, the efficacy of different lasers was the same, though the long-pulsed alexandrite had a higher risk of transient erythema, edema, crusting, dyspigmentation, and hair induction.³⁶

Procedure

Using the flexible handpiece, an appropriate spot size, fluence, and pulse duration are selected. It is recommended that an inconspicuous test spot should be performed before treating the full area to check the settings and ensure an appropriate therapeutic endpoint of skin erythema without erosion, char, or sloughing. One study of 36 patients showed equivalent 6-month efficacy for pulse durations of 5-, 10-, and 20-ms pulse durations using a 10-

mm spot size and fluences ranging from 15 to 20 J/cm². Hyperpigmentation occurred in all treatment groups, but was less severe and more transient in the 20-ms pulse duration group.²⁷

Special considerations

An alexandrite laser is a good choice for LHR in types I to III skin (though it can be used up to skin type IV), and is generally fairly effective and well tolerated. Caution should be exercised in using alexandrite lasers in darker-skinned patients due to the increased risk of adverse events.

Diode

Introduction

Diode lasers are based on the use of semiconductors such as gallium arsenide and aluminum gallium arsenide, and have wavelengths of 755,³⁸ 800 to 810, 940, and 980 nm.^{7,39} Laser hair removal is usually performed with 800- to 810-nm diode lasers, although a newer 755-nm diode laser has been developed and was shown to have efficacy in a single patient study comparable to a 755-nm alexandrite laser.³⁸ The advantage of diode lasers is that they are relatively small and compact, and of generally lower cost.³⁹ The longer wavelength allows deeper penetration into the skin, which allows improved treatment of the hair follicle while limiting damage to the epidermal melanin.⁴⁰ This laser type can be used to treat patients with Fitzpatrick skin types I to IV or V.⁷ The hair count reduction of the long-pulsed diode laser ranges from 22% to 74%, depending on the study and number of treatments administered.^{4,29,41–45} Grunewald et al. saw hair reduction rates of 74% that persisted after 18 months, using a fluence of 24 to 30 J/cm², a pulse duration of 12 ms, and a spot size of 50 × 12 mm for a total of six treatments.⁴⁶

Like the other hair removal modalities, repeat treatments are important for success. One study found that after two treatments, the mean hair reduction is 28%, which increased to 78% after three treatments.⁴⁷ Studies on the appropriate interval between treatments are lacking, but one study found that

shorter treatment intervals led to more hair reduction, with 45-day intervals performing better than 60- and 90-day intervals.⁴⁷

Procedure

The clinician should choose appropriate settings based on the patient's skin type, prior experience, and settings available on the particular machine. Spot size may affect efficacy in addition to speed of treatment. One study found that keeping fluence, pulse duration, and epidermal cooling constant between groups, a larger spot size of 10×30 mm had a 50% mean hair clearance compared to 39% for a spot size of 10×10 mm.⁴⁸

If there is a cooling tip, the handpiece should be placed firmly and directly on the area to be treated for about 0.5 seconds to allow the epidermis to cool, and the laser pulse should then be delivered. Firm pressure also compresses the skin, effectively decreasing the depth of follicular structures and concomitantly blanching the underlying vasculature, which helps minimize laser energy absorption of the competing chromophore oxyhemoglobin.⁴²

While the diode is not the laser of choice for patients with types V or VI skin, for patients with medium skin tones, the clinician should start with lower fluences and wider pulse widths for patients with darker-colored skin. The use of a diode laser with darker skin types is associated with a higher risk of blistering and either temporary or permanent dyspigmentation than in lighter-skinned patients.⁴⁹ If blistering occurs, standard skin wound care measures are recommended.

Special considerations

Classic diode lasers are appropriate for treatment of types I to IV skin. With some newer contact cooling technologies, diode lasers may be safe for treatment of type V skin, though a test spot should always be performed. Ensuring complete skin contact is important when using contact-based cooling. It is important to note that patients may sometimes inadvertently move and create distance between the cooled tip and the skin and increase the risk of blister formation.

Nd:YAG

Introduction

The Nd:YAG laser emits 1,064-nm light in the infrared spectrum. Of all the laser systems used for hair removal, the 1,064-nm Nd:YAG is considered the safest laser for hair removal in darker skin types⁵⁰ and can be used in all skin types.^{51–53} The Nd:YAG has the deepest depth of penetration and a wavelength that is at the tail end of the melanin absorption curve, so it better bypasses epidermal melanin. However, it is also one of the least effective of the hair removal light-based therapies.^{32,52} In one study comparing alexandrite, diode, and Nd:YAG, the percentage of hair reduction was 70.3%, 59.7%, and 47.4%, respectively.³² One study specifically looking at the use of IPL versus Nd:YAG in patients with types IV to VI skin found better efficacy and patient satisfaction with the Nd:YAG laser.⁵⁴

Overall, the Nd:YAG laser has been found to have hair reduction rates ranging from 27% to 79%,^{32,54,55} with more treatments (5–6) associated with more hair reduction.⁵⁶ One study also found that treatment for laser hair removal also incidentally led to a decrease in sweating in the axillae.⁵⁷

Procedure

After ensuring that all the equipment is functioning appropriately, cleaning the skin, and making sure the hair is shaved to <1 mm, the clinician should next conduct a test spot. A test spot is particularly important in patients with darker skin who are undergoing laser hair removal to avoid using settings that will lead to adverse effects. The test spot should show appropriate perifollicular erythema and edema without signs of overtreatment, for example, immediate graying, blistering, vesiculation, or induced epidermal sloughing. When the appropriate settings are chosen, proceed with covering the area with slightly overlapping pulses to achieve uniform treatment.

Special considerations

The Nd:YAG laser is appropriate for hair removal in all skin types, though care should be taken to reduce the fluence and perform a test spot prior to treating the whole area. Repeat treatments are typically necessary, with the amount of hair removal proportional to the number of treatments administered. While this laser is the best choice for hair removal in patients with darker-colored skin, treatment of fine hairs in these patients is still

difficult because the fluences required for hair reduction may be associated with increased risk of adverse effects in this population.⁵⁸

Intense pulsed light

Introduction

In contrast to the traditional lasers discussed so far, IPL is a xenon polychromatic broadband flash lamp that emits wavelengths from 500 to 1,200 nm. With IPL, energy stored in a computer-controlled capacitor bank is released and passed through xenon gas, leading to conversion of electrical energy into optical energy and the emission of a bright light.⁵⁹ Optical filters are used to further restrict noncoherent light beams to a therapeutic range. Both lasers and IPL operate based on the concept of photothermolysis, though IPL emits a spectrum of light rather than a single wavelength. IPL therefore allows the treatment of several different chromophores at one time. For instance, melanin has an absorption spectrum from 250 to 1,200 nm. Oxyhemoglobin has absorption peaks at 418, 542, and 577 nm, and collagen fibers absorb light in the 400- to 600-nm range.⁶⁰ Because of the competing chromophores, filters for light below 620 nm are often used with IPL for hair removal to more selectively target melanin. The broad range of wavelengths emitted allows versatility in treatments and the ability to target multiple, different problems at once. However, this feature also requires well-trained clinicians to avoid inadvertently causing nonspecific thermal damage.¹ In most IPL systems, the pulse duration ranges from 0.2 to 100 ms, and it should generally be set to be less than the thermal relaxation time of the intended target.⁶⁰

IPL offers several advantages and disadvantages compared to lasers. IPL is relatively lower cost and has a large handpiece that can be used to quickly treat large surface areas. However, that large handpiece can also be heavy and cumbersome, and the need for direct skin contact makes it more difficult to see the site and immediate effects of the area that is being treated. IPL also does not typically yield the same immediate local visible skin changes as lasers, so it is more difficult to delineate treated from untreated areas, leading to potential treatment gaps or pulse stacking. Finally, depending on the unit used, the emitted spectrum and fluence can vary from pulse to pulse,

particularly if the capacitor bank is small. This variation can potentially lead to inconsistent or less predictable results.⁵⁹

Efficacy of IPL ranges from 34% to 85% hair reduction at 6- to 12-month follow-up.^{61–67} In comparison with diode,^{61–64,68} alexandrite, and Nd:YAG, IPL was found to lead to the same or inferior results. Of the studies comparing diode and IPL, two studies found that patients had more pain with diode treatment,^{61,64} and the other showed greater pain with IPL treatment.⁶³

The use of filters for IPL depends on the treatment indication, and in laser hair removal, wavelengths below 620 nm are typically filtered out. Because of the broad spectrum of light applied with IPL, it is most appropriate for patients with skin types I to III, though can be used with caution in patients with skin type IV. Higher skin types require longer wavelengths, longer pulse durations, and effective epidermal cooling to help prevent adverse effects.

Procedure

After appropriate equipment checks, skin preparation, and safety checks, the procedure may be started. Both the clinician and patient should wear broad-spectrum eye protection appropriate for IPL. An optical coupling gel should be placed on the surface of the skin. A test spot in an inconspicuous location may be performed in order to evaluate for potential adverse effects as well as therapeutic efficacy of the chosen settings. When treating an area, there should be <10% overlap between spots, and melanocytic lesions or tattoos that are incidentally in the treatment area should be avoided or covered with nonabsorbent white paper.⁵⁹

Special considerations

In IPLs that use dichroic filters to filter out unwanted wavelengths of light, 10% to 15% of the filtered wavelengths can still pass through and have the potential to cause epidermal damage. Therefore, methods of protecting the epidermis, such as cooling, are very important regardless of the filter used.⁶⁹

POSTPROCEDURE

The clinician should look for immediate perifollicular edema and erythema as a therapeutic endpoint (Fig. 66-1), except for the IPL, where posttreatment effects are not always apparent. The area can be cooled for comfort with wet

gauze, cool compresses, ice packs, cold gel packs, or forced cool air. The use of a lower to medium potency topical corticosteroids is dependent on the clinician's preference and treatment site, but should be more strongly considered in case of burns, blistering, erosions, or more inflammatory reactions in darker-skinned patients. The patient should be informed that it may take several weeks for the hair to shed, and to take care with sun avoidance to decrease the risk of postinflammatory hyperpigmentation. Repeat treatments should be performed in 4 to 6 weeks.

COMPLICATIONS

Despite the frequency of laser hair removal, significant or severe side effects are still rare. Many of the complications that can be seen with laser therapy are common to different types of lasers and light-based therapies. Patients can experience pain, blistering, erosions, hyperpigmentation, hypopigmentation, folliculitis, crusting, and very rarely permanent scarring.⁷⁰⁻⁷² Epidermal damage can occur with inadequate or dysfunctional cooling. This complication can also occur if hair is not adequately shaved. The charred hair can accumulate on the cooling tip during treatment without being recognized, interfering with the functionality of the cooling tip. Unwanted side effects may arise from choosing a laser or light device with inadequate cooling or light wavelengths that compete for melanin in darkly pigmented patients. For example, IPL treatment for hair reduction in skin of color may result in burns that present as linear erythema, and subsequent postinflammatory dyspigmentation and/or scarring (Fig. 66-2).⁷³



Figure 66-1. The clinician should look for immediate perifollicular edema and erythema as a therapeutic endpoint.



Figure 66-2. IPL treatment for hair reduction in skin of color may result in burns that present as linear erythema, and subsequent postinflammatory dyspigmentation and/or scarring.

While rare, there have been reports of patients experiencing paradoxical hypertrichosis within or near treatment sites, also termed terminalization, induction, and terminal hair growth.^{74–80} All lasers are thought to have the potential to induce terminalization of hairs, with an estimated incidence ranging from 0.6% to 10% (although the 10% estimate was found in a

nonrepresentative patient population).⁷⁵ In situations where there is increased hair growth at adjacent, untreated sites, the causal relationship between laser treatment and terminal hair growth is undetermined, since it seems unlikely that the optical energy is directly responsible for changes in the dermal papillae that ultimately determine hair type.⁷⁶ Risk factors for paradoxical hypertrichosis include obesity, polycystic ovarian syndrome, androgen hormonal irregularities, darker skin phenotype, and middle age.⁷⁶ The mechanism of this phenomenon is unknown. Increasing fluences and changing laser wavelengths can sometimes successfully reverse paradoxical hypertrichosis, but some cases do not respond and only continue to worsen.

The development of Fox-Fordyce disease (FFD) or apocrine miliaria is a newly described complication of LHR therapy.^{81–85} Patients typically present with monomorphic skin colored to yellowish, pruritic, follicular, or perifollicular papules that are classically limited to apocrine areas. The pathogenesis of FFD is unknown, but it is thought that keratinocyte dysfunction leads to follicular plugging with subsequent dilation and extravasation of sweat into the surrounding tissues, leading to a chronic inflammatory response.⁸¹

While performing laser hair removal, the clinician should try to avoid the treatment of melanocytic nevi in the field. The long-term sequelae and effects of laser therapy on melanocytic nevi are unknown, and there have been reports of changing nevi following diode laser treatment for hair removal.⁸⁶ The treatment of melanocytic nevi is controversial, and there have been several cases reported of melanoma either arising or discovered after laser therapy, arguing that laser clinicians should be cautious in their use of lasers on pigmented lesions.^{87–90} Additionally, treatment over a tattoo can lead to burns because of pigment absorption of laser energy.⁹¹

OTHER TECHNOLOGIES: RADIOFREQUENCY AND MICROWAVES

There have been other technologies based on electromagnetic energy that have been used for laser hair removal, such as radiofrequency and microwaves.

Radiofrequency hair reduction

In one study, researchers used a combination of IPL and radiofrequency in patients with white- or light-colored hairs. The concept behind the combination of energy sources was the ability to apply a level of optical energy that is safe for all skin types while compensating for the reduced laser intensities with the additional radiofrequency energy. They used fluences of 24 to 30 J/cm² and RF energy of 20 J/cm³. They found an average of 52% clearance with blonde hair and a 44% clearance of white hair, and overall an 80% to 85% clearance in darker-haired patients after four treatments. However, the study lacked a control or other comparison group.^{92,93}

Microwave hair reduction

A new device using microwaves (MiraSmooth) was recently FDA cleared for hair reduction. It uses microwaves to heat the area of treated skin, which leads to destruction of sweat glands and hair follicles and concurrent decrease in sweating, as well as hair reduction. While long-term and larger studies are lacking so far, one small study of seven people found an average hair reduction of 43%.⁹⁴

CONCLUSIONS

Hair reduction is the most common laser- and energy-based device treatment performed in the United States. There are a variety of laser- and energy-based device methods to reduce hair, and technical innovations in hair reduction continue to occur. These methods are generally safe for patients and yield excellent outcomes, and an appreciation of the range of devices and their appropriate application to the desired patient population is of significant value to the dermatologic surgeon.

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CHAPTER 67 Laser Resurfacing

Marc Z. Handler

David J. Goldberg



SUMMARY

- Skin resurfacing is a common aesthetic procedure, and can result in improvement in rhytides, skin texture, dyspigmentation, and skin tightening.
- Several laser and energy devices are available, and they can broadly be divided into ablative nonfractional lasers, nonablative nonfractional lasers, ablative fractional lasers, and nonablative fractional lasers.

Beginner Tips



- There is generally a tradeoff between efficacy, or number of required treatments, and the amount of downtime that a patient can expect.
- Ablative nonfractional lasers have the most dramatic effect for resurfacing, but also the greatest downtime. At the other end of the spectrum are nonablative fractional lasers, which require the most treatments but have the least downtime.

Expert Tips



- Closely overlapping fractional laser pulses can lead to the MTZs blending together, resulting in a nonfractional result.
- Needed treatment energy and density is not uniform across the face; select areas may require increased fluence or an increased density.

Don't Forget!



- Ablative nonfractional lasers may lead to dramatic improvement after a single treatment, but other approaches generally require a series of multiple treatments.
- When combining PDL or IPL and resurfacing lasers, be sure to treat for erythema before resurfacing so that the immediate postprocedure erythema is not the target of the PDL or IPL.

Pitfalls and Cautions



- Ablative nonfractional lasers should generally not be used in skin types V to VI, given the risk of dyspigmentation and scarring.
- The rate of acneiform eruptions and milia formation for laser resurfacing remains fairly high, and this should be discussed with patients preprocedure.

Patient Education Points



- For all treatments other than ablative nonfractional lasers, patients should be told to expect several treatment sessions before seeing meaningful results.
- Patients should have realistic expectations regarding the healing process, and should be warned that they will be out of commission for up to 2 weeks with ablative nonfractional lasers.

Billing Pearls



- Almost all insurers in the United States exclude laser treatments from coverage.
- Patients may benefit from committing to a series of treatments, as this may allow significant cost savings.
- Pretreatment with occluded topical anesthesia can be started at home, and prescription plans may cover the cost of this medication.

CHAPTER 67 Laser Resurfacing

INTRODUCTION

Skin resurfacing with energy-based devices decreases dyspigmentation, reduces rhytides and improves texture. Tighter skin is made possible through thermal damage to dermal collagen bundles and stimulation of dermal fibroblasts. In order to produce dermal collagen damage, energy is transmitted through the epidermis and into the dermis at a minimum temperature of 65°C, the temperature required to damage collagen.

Originally, energy devices required destruction of the epidermis along with the dermis. These ablative nonfractionated lasers are effective at collagen destruction, but also cause full epidermal destruction, requiring a significant recuperation period. Lasers that do not destroy the epidermis, but produce heat in the dermis, are referred to as nonablative lasers. They do not require the same duration of recovery, but necessitate a greater number of treatments to achieve appreciable results. The abbreviated recovery time following fractionated laser resurfacing reflects the creation of microscopic treatment zones (MTZs) that allow faster epidermal healing while thermally heating dermal collagen. Radiofrequency (RF) devices are not lasers, but utilize the same premise as resurfacing laser devices. Utilizing RF, the dermis is heated to a temperature that damages collagen and stimulates fibroblasts, while avoiding epidermal destruction. Each energy-based device has benefits and drawbacks. One device may produce faster results but require extensive downtime, while another may have an increased risk of hypopigmentation when used to treat a patient with a darker skin type.

ABLATIVE NONFRACTIONATED LASERS

Since their 1964 invention at Bell Laboratories until the 1990s, the only dermatologic energy-based device for the treatment of scars, rhytides, dyspigmentation, and surface texture was an ablative nonfractionated carbon dioxide (CO₂) laser.¹ Ablative lasers are excellent at resurfacing, as they instantly heat epidermal cells to greater than 100°C, leading to vaporization of the surface cells and produce coagulation necrosis of the residual cellular layer. In the dermis, the energy emitted from the laser creates nonfatal damage to dermal fibroblasts, stimulating collagen production, resulting in decreased rhytides, resolution of dyspigmentation, and smoother skin. Currently available laser platforms for ablative lasers are CO₂, which emits energy at 10,600 nm, and erbium:yttrium aluminum garnet (Er:YAG), which emits at 2,940 nm.

In their nonfractionated form, ablative lasers vaporize the entire field of skin on which they are projected. As with other skin rejuvenation lasers, the thermal damage produced denatures the existing dermal collagen and stimulates the production of new collagen. New collagen synthesis may continue 4 to 6 months after treatment.¹ As collagen is generated, the wound heals with subsequent tightening of the dermis and epidermis, resulting in improved skin texture.²

Nonfractionated ablative CO₂ lasers produce excellent improvement in skin texture, dyspigmentation, and rhytides,³ but require a 2-week recovery period from edema, burning, and crusting, and carry an average of 4 months of treatment site erythema.^{1,4} There is also a risk of permanent hypopigmentation, herpes simplex virus (HSV) outbreak, scarring, milia formation, and acne flare.^{5,6} Ablative nonfractionated Er:YAG lasers, which were developed after ablative nonfractionated CO₂ lasers, when used with longer pulse duration produce results equal to their CO₂ counterparts, but with less unintentional tissue destruction, shortening the patient's recovery period.

CO₂ and Er:YAG nonfractionated ablative lasers are used only for patients with light skin types. Dyspigmentation risk and scarring among Fitzpatrick skin types V and VI is considered too great to consider this group for nonfractionated ablative resurfacing treatment (Figs. 67-1 and 67-2).⁷



Figure 67-1. Before ablative carbon dioxide laser resurfacing.

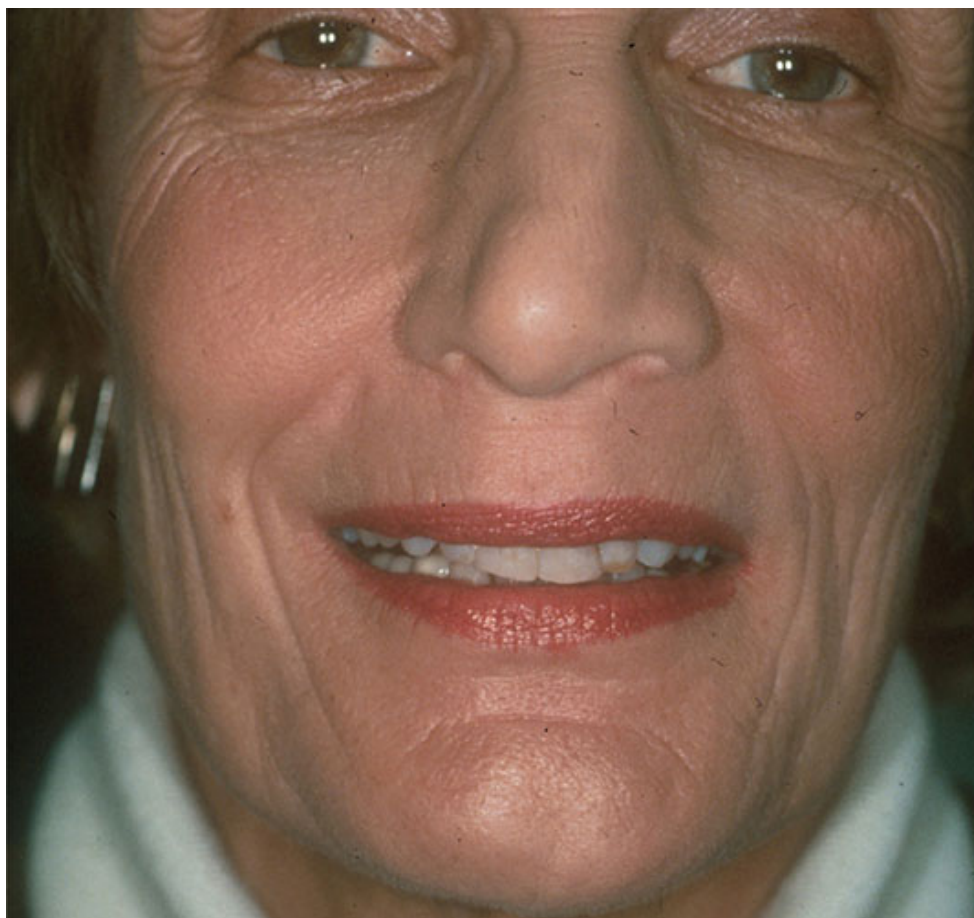


Figure 67-2. Six months after laser resurfacing.

NONABLATIVE NONFRACTIONATED LASERS

The development of nonablative nonfractionated lasers near the end of the twentieth century provided an alternative to ablative laser devices. Devices include the 1,450-nm diode (Candela Smoothbeam), 1,320-nm Nd:YAG (CoolTouch CT3Plus and Alma Harmony XL), and 1,319-nm pulsed energy (Sciton ThermaScan). Nonablative lasers use milder heat that will not vaporize tissue, but will denature target proteins, such as dermal collagen. In contrast to their ablative brethren, nonablative nonfractionated lasers produce less radical cosmetic results per treatment, but have drastically reduced healing times, which may limit erythema to a single post-treatment afternoon.^{8,9} As with ablative nonfractionated lasers, 80% of patients treated

with nonablative nonfractional lasers will develop a transient acneiform eruption, and 14% develop transient milia.¹⁰ An additional benefit of nonablative lasers is a decreased risk of hypopigmentation in darker skin types (Fitzpatrick skin types V and VI), as compared to ablative lasers.¹¹

NONABLATIVE FRACTIONAL LASER

In 2005, nonablative fractional laser resurfacing (NAFR) entered the market.¹² Unlike nonfractionated lasers, fractionated lasers produce MTZ one-tenth of the diameter of a hair follicle scattered throughout the treatment field. The MTZ depth may be set between 0 and 550 μm with diameter ranging from 50 to 150 μm . As a nonablative laser, the heat targets the dermis and does not vaporize the stratum corneum, leaving a natural bandage covering the coagulated tissue of the damaged epidermis and dermis. The creation of MTZ leaves surrounding keratinocytes uninjured and promotes faster healing than full-field ablative lasers, while still stimulating dermal fibroblasts and collagen formation.

There is an increased desire for resurfacing technologies for patients of skin types V and VI.⁷ Those with darker skin types have increased epidermal melanin, larger melanosomes that are widely distributed within epidermal keratinocytes, and more reactive fibroblasts and melanocytic responses. These features increase the tendency to develop dyspigmentation after exposure to laser light.⁷ As with the nonablative nonfractionated devices, nonablative fractionated lasers (non-AFLs) are safer in Fitzpatrick skin types up to VI than ablative lasers, and allow patients a more rapid post-treatment recovery.⁶ Current devices on the market include 1,440-nm Nd:YAG (Cynosure Affirm, Palomar StarLux), 1,550-nm Erbium glass (Solta Fraxel re:store), 1,565-nm fiber (Lumenis ResurFx), and 1,927-nm thulium fiber (Solta Fraxel re:store Dual). Erbium-doped 1,550-nm nonablative lasers (Fraxel re:store Dual 1,550 nm) have been successful in resurfacing acne scars in Fitzpatrick skin types IV to VI,¹³ but with a significant incidence of self-limited postinflammatory hyperpigmentation among those with Fitzpatrick skin types IV to VI. Preoperative treatment with hydroquinone does not diminish this risk.¹³ Unlike nonfractionated lasers, only 10% of patients treated with NAFR will develop an acneiform eruption, and 19%

will develop milia.¹⁰ In addition to rhytides, NAFR has been successfully used in the treatment of hypertrophic scars, including those resulting from surgical procedures, such as Mohs surgery.¹⁴ When treating scars with an erythematous component, it is recommended to initially treat with a vascular laser, such as a pulsed-dye laser (PDL), and then NAFR, to ensure that the PDL is treating the vascular component of the scar, not the erythema from the NAFR.¹⁵ For erythematous surgical scars, a protocol of PDL treatments every 4 weeks followed by NAFR has been suggested. Eilers et al.¹⁵ recommend settings of 30 to 50 mJ and 20% to 39% density for NAFR resurfacing of hypertrophic surgical scars (Figs. 67-3 to 67-6).¹⁵

ABLATIVE FRACTIONATED LASERS

Use of AFLs began in 2007. These lasers create MTZ while sparing the surrounding tissue, allowing for rapid healing and little downtime. Both nonablative and AFLs are able to penetrate to the same depth, dependent on settings, with the ablative form vaporizing tissue. Most patients develop postprocedural edema and erythema, lasting up to 3 days.¹ Studies have demonstrated significant improvement of acne scars from both CO₂ and Er:YAG AFL devices (Figs. 67-7 to 67-14).¹⁶



Figure 67-3. Before nonablative ablative fractional resurfacing.



Figure 67-4. Six months after four sessions of nonablative fractional resurfacing.



Figure 67-5. Before nonablative ablative fractional resurfacing.



Figure 67-6. Six months after four sessions of nonablative fractional resurfacing.



Figure 67-7. Before ablative fractional carbon dioxide laser resurfacing.



Figure 67-8. Six months after ablative fractional carbon dioxide laser resurfacing.



Figure 67-9. Before ablative fractional carbon dioxide laser resurfacing.



Figure 67-10. Six months after ablative fractional carbon dioxide laser resurfacing.



Figure 67-11. Before ablative fractional carbon dioxide laser resurfacing.



Figure 67-12. Six months after ablative fractional carbon dioxide laser resurfacing.



Figure 67-13. Before and 6 months after ablative fractional Er:YAG laser resurfacing.



Figure 67-14. Before and 6 months after ablative fractional Er:YAG resurfacing.

Ablative fractional CO₂ has successfully been employed in the treatment of smooth elevated surgical scars in patients with skin types I to IV.^{16,17} Ciocon et al.¹⁸ performed a split-face trial comparing efficacy, efficiency, and tolerability between a device with a stamping handpiece (UltraPulse Encore Deep FX, Lumenis) and a device with a rolling handpiece (Fraxel repair, Solta Medical). Results demonstrated equal efficacy, but the rolling handpiece was reported to produce less pain and be more efficient for the operator.¹⁸

In another study, Korean patients with skin types III to IV were treated with both an 2,940 nm Er:YAG (Matrixell, Medro) with 10 to 20 passes per lesion at 2.5 to 3.0 J for 3- to 4-week intervals for a total of two to seven treatments, or alternatively treated with 10,600 nm CO₂ (eCO₂, Lutronic) at 40 to 60 mJ with 150 spots/cm² and three to five passes in static mode for a total of one to nine treatments every 4 to 8 weeks.¹⁹ Among the AFLs tested, Er:YAG improved the scars an average of 28.2% and the CO₂ improved scars by an average of 49.8%.¹⁹ Adjuvant therapies such as the addition of autologous platelet-rich plasma have been studied, but have not been shown to improve resurfacing when used in conjunction with CO₂ AFL.²⁰

Both CO₂ and Er:YAG lasers are effective at ablative tissue resurfacing and require a similar re-epithelialization time of 8 to 14 days.^{21,22} In addition to downtime from re-epithelialization, there may be associated psychological distress resulting from treatment-area erythema. Er:YAG lasers produce energy at a wavelength of 2,940 nm, with 10 times more water absorption than CO₂ lasers. This allows a reduction in thermal damage, correlating to a reduction in scarring, while maintaining high superficial tissue ablation. In contrast, the efficacy of the CO₂ laser in the treatment of deep rhytides, resulting from its production of deeper coagulation with fewer passes, is superior to the Er:YAG.²²

The erbium:yttrium scandium gallium garnet (Er:YSGG), a 2,790-nm mid-infrared laser, originally tested in the 1990s,²³ is between the CO₂ and Er:YAG.²⁴ The Er:YSGG laser destroys the epidermis 10 to 30 µm in depth and coagulates the epidermis with heat. The Er:YSGG has a tissue absorption coefficient five times greater than CO₂ but one-third that of Er:YAG, thus producing greater thermal damage and neocollagenesis and

elastinogenesis in the proliferative stage of wound healing than an Er:YAG laser, but its limited depth of thermal injury produces less postoperative pain compared to a 10,600-nm CO₂ laser.^{24,25} The remodeling phase that follows the proliferative stage results in a tighter dermis and removal of epidermal wrinkles.²⁶ The Er:YSGG laser has successfully been tested for scar treatment, pore treatment, wrinkle reduction, and skin tone improvement.²⁶ In a single-blinded trial of 10 subjects with skin types II to III, a two-pass facial treatment, first at 226 J/cm² and then at 283 J/cm², at a total density of 16% to 24%, demonstrated moderate or greater improvement among 60% of subjects' perioral wrinkles and 50% of subjects' full-face wrinkles and fine lines.²⁷ There was persistent erythema in 20% of patients at the 6-month mark, but no serious adverse events.²⁷ In a split-face trial of 920 μ b/cm² fractional ablative Er:YSGG and Er:YAG, Er:YAG demonstrated greater periorbital wrinkle reduction with fewer required passes.²⁸ With regard to perioral wrinkle reduction, the Er:YSGG demonstrated no improvement after a single pass that was greater than 2 on a 0 to 9 scale, while the Er:YAG, using a one-to-two stacked pass technique, demonstrated a 57% improvement greater than 2, on a 0 to 9 wrinkle scale.²⁸

The benefit of the fractional ablative treatment is rapid healing after treatments, but it is important to minimize the number of passes, as if the MTZs merge or overlap then the procedure is similar to an ablative resurfacing. In a blinded study by Munavalli et al.,²⁵ subjects were treated with an Er:YSGG laser with combined ablative and fractional ablative capabilities for study of treatment of superficial and deep skin changes from photoaging. Among 10 enlisted subjects, limited to skin types I to III, 80% of patients were rated as having a moderate to very significant improvement of their wrinkles and overall photoaging at 6-month postprocedure.²⁵ An 11-patient 6-week follow-up study of the Er:YSGG laser found 56% of patients had an improvement between 26% and 75% in dyschromia and 18% had improvement in that range of wrinkles.²⁹ No patient had greater than 51% improvement in their overall appearance 6 weeks after Er:YSGG laser.²⁹ The YSGG results in minimal downtime, 5 days of erythema at treatment sites, and a 50% to 89% reduction in acne scars in 70% of Fitzpatrick skin type IV to V patients.³⁰

RADIOFREQUENCY

RF devices are an important tool in photofacial resurfacing. Their energy penetrates into the reticular dermis, but unlike lasers, avoids heating the skin surface. Similar to lasers, the energy transferred to the dermis stimulates denaturation of the existing collagen and promotes generation of new, shorter collagen bundles.³¹ Collagen, which denatures after 10 minutes at 65°C, shrinks by 10%, resulting in tightening of the skin. This is independent of chromophore interaction, and does not interfere with melanin in the epidermis.³² Approved by the FDA in 2008 for atrophic acne scars, RF has shown acne scar improvement in split-face studies.³³ A study among 30 Thai subjects with skin types III to V, demonstrated significant acne scar reduction with either 60 mJ/pin or 100 mJ/pin. Subjects were not provided anesthetic, and noted increased procedural pain with the higher energy setting. Neither group developed postinflammatory hyperpigmentation lasting longer than 4 weeks.³³ Similar findings have been demonstrated in skin types I to III.³⁴ Another study, of skin types III to IV, found 80% of subjects demonstrating a 50% or greater improvement of acne scars when treated every 4 weeks for 12 weeks with combined microneedling and fractional RF.³⁵

Bipolar RF devices deliver energy to the skin in fractionated thermal zones with a pyramid-shaped output, thereby minimizing heat within the epidermis.^{6,36} Among those treated with bipolar RF devices, 61%, 35%, 78%, 87%, and 83% of all treated patients have reported a 50% improvement or greater, of their fine lines, pores, tightness, brightness, and overall appearance, respectively, 6 weeks after treatment.³⁷ Some RF devices, called fractional RF systems, create microablative resurfacing of the epidermis, and enhance collagen and elastin production in the dermis.^{38,39} As with other RF devices, there is stimulation of collagen production with minimal down time.⁶ Adverse events are typically limited to posttreatment erythema and crusting.⁴⁰ Microneedling has become increasingly used for treatment in facial resurfacing. Microneedles placed into dermal collagen induce collagen production and the addition of fractional ablative needle RF.^{41,42} A study from Egypt among patients with Fitzpatrick skin types III to IV used a monopolar RF device with cryogen unit or cooling (Biorad, Shenzhen GSD Tech Co) with two passes of 150 J to the face (except for 200 J applied

to the periorbital, nasolabial, and forehead areas). After 3 months, there was 70% to 75% improvement in skin tightening and 90% to 95% improvement in facial rhytides.⁴² The researchers observed new collagen synthesis on histologic analysis in those treated. Repeated studies have demonstrated that multiple passes are more beneficial than a single pass at denaturation of collagen. The most common side effect was erythema lasting less than 24 hours and mild edema, which may last up to 1 week.⁴³ RF allows for treatment of patients with any skin type. A study of 15 subjects, skin types V to VI, were treated with 30 to 50 mJ from a fractionated bipolar RF device (e-Matrix, Syneron Medical Inc.).³² After three monthly treatments, greater than 85% of subjects had improved tone, texture, and a decrease in fine lines and wrinkles (Figs. 67-15 to 67-18).³²



Figure 67-15. Before fractional RF resurfacing.



Figure 67-16. Immediately after fractional RF resurfacing. Note minimal erythema in darker-skinned patient.



Figure 67-17. Before fractional RF resurfacing.



Figure 67-18. Six months after fractional RF resurfacing. Note tightened skin and improved nasolabial folds in darker-skinned patient.

POSTPROCEDURE CARE

After laser treatment, patients should apply noncomedogenic moisturizers to mitigate the risk of acneiform eruptions and milia. In patients with anticipated severe acne flares, oral tetracycline may be provided.⁴⁴ If the patient was treated with a non-AFL, erythema should be expected for up to 4

days.⁴⁵ If the laser was ablative, erythema may last 4 weeks. Postinflammatory hyperpigmentation is most commonly observed in those with Fitzpatrick skin types III to VI.^{44,46} The risks of treatment of a patient with skin types III to VI with a nonfractional ablative laser typically outweigh the benefits.^{10,46,47} Additional recommendations are to minimize sun exposure 2 weeks before and after treatment and be religious with sunscreen use. Development of HSV reactivation occurs in up to 2% of those treated with non-AFLs.⁴⁸ Among those treated with nonfractionated ablative lasers, the incidence may be as high as 7%.⁴⁹ To reduce the risk of an HSV eruption, oral antivirals may be given for 5 to 7 days, beginning the day of, or the day prior to, the procedure.

Patients treated with fractional lasers may rarely experience delayed purpura 3 days after treatment. For this reason, anticoagulants such as aspirin and other nonsteroidal anti-inflammatory agents are not recommended.⁵⁰ Rarely reported recall phenomena have been described with patients treated with fractional lasers. A transient, benign, erythematous patch may appear after a hot shower or sunlight exposure in the previously treated areas.⁵¹ In those treated with RF devices, erythema and scabs may develop, in addition to pain that is experienced by up to 88% of patients.³⁷ A reported side effect of monopolar RF treatment is loss of adipose tissue due to heating, which may lead to contour irregularities.^{52,53}

CONCLUSIONS

There have been significant advances in energy-based resurfacing devices over the past three decades. Five major classes of resurfacing devices are available, including ablative fractionated, ablative nonfractionated, nonablative fractionated, nonablative nonfractionated, and RF devices. Combination devices have been studied, and demonstrated efficacy in facial skin resurfacing.⁵⁴ Choice of device depends on a patient's skin type, acceptance of postoperative downtime, and desired outcome. Technological advancements continue to be made on energy-based resurfacing with a focus on maximizing cosmetic efficacy while minimizing subsequent postoperative pain, dyspigmentation, desquamation, and erythema.

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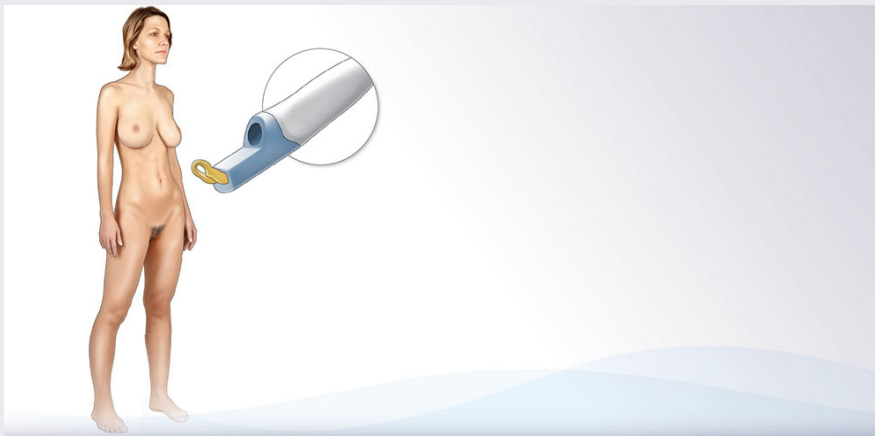
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CHAPTER 68 Body-Contouring Devices and Noninvasive Fat Removal

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SUMMARY

- Liposuction is now the second most frequently performed cosmetic procedure in the United States.

- Approaches to noninvasive body contouring include cryolipolysis, high-intensity focused ultrasound (HIFU), low-level laser therapy (LLLT), hyperthermic lasers, radiofrequency, and infrared lasers.
- These approaches to noninvasive fat removal all selectively target components of adipose tissue.
- All minimally invasive body-contouring technologies fall far short of liposuction in terms of clinical efficacy and rapidity of response.

Beginner Tips



- No head-to-head studies have been performed comparing various technologies for body contouring.
- Be sure to closely investigate the various options before purchasing a device, as some systems require a significant ongoing expenditure on consumables, while others do not.

Expert Tips



- Patient selection is critical, as the degree of response seen with body contouring may be relatively modest.

- Most body-contouring approaches should only be used for patients with a BMI in the normal range.
- Combination therapies are a reasonable option for many patients.

Don't Forget!



- Some treatments, such as cryolipolysis, take several months to demonstrate complete benefit. Therefore, appropriate planning is important for patients aiming to improve their body profile before a major event.
- While all treatments are minimally invasive, some lead to more significant postoperative edema and ecchymosis.

Pitfalls and Cautions



- Paradoxical adipose hyperplasia may be rarely seen after cryolipolysis.
- If it occurs, spontaneous resolution is not expected; therefore patients should always be warned of this rare possibility.
- While there is a theoretical risk of LFT and lipid changes during the fat resorption phase, this has not been reported clinically.

Patient Education Points



- Multiple treatments may be required.
- No minimally invasive treatment can match liposuction in terms of efficacy, flexibility, and rapidity of response.
- Realistic expectations are critical, and patients who expect a dramatic response should probably be warned against this approach.

CHAPTER 68 Body-Contouring Devices and Noninvasive Fat Removal

INTRODUCTION

The number of cosmetic procedures has soared over the past decades, with liposuction the second most popular cosmetic surgical procedure performed in the United States.¹ Despite its popularity and overall safety, liposuction is an invasive surgical procedure with risks including infection, complications from anesthesia, and even death. Therefore there is demand for noninvasive approaches that may lead toward the ideal physique with less risk and downtime. Multiple body-contouring devices have been created over recent years to meet these demands such as cryolipolysis, low-level laser therapy (LLLT), high-intensity focused ultrasound (HIFU), radiofrequency (RF), and infrared lasers.^{2,3} These new approaches to noninvasive fat removal all selectively target components of adipose tissue that differentiate it from the overlying epidermis and dermis.⁴

CRYOLIPOLYSIS

Cryolipolysis dates back to the 1970s, when Epstein and Oren observed a red indurated nodule followed by transient fat necrosis on the cheek of an infant who had been sucking on a popsicle. They termed this phenomenon “popsicle panniculitis,” which led to the discovery that adipose tissue is

more susceptible to cold injury than surrounding tissue, a concept now referred to as “cold-induced panniculitis.”⁵ This idea was first exploited by Manstein et al. in 2007, who performed the initial studies exploring the selective destruction of fat.⁶ Using black Yucatan pigs, copper plates were applied at various temperatures (−8, −7, −5, −3, −1, and 20°C) to a test site for 10 minutes. These areas were studied grossly and histologically at different time points, with the longest one being 3.5 months. They found that cooling induced a lobular panniculitis, and the amount of fat damage increased up to a month after exposure. This study was followed up by Zelickson et al. in 2009 using three pigs that underwent a single cryolipolysis treatment.⁷ They assessed the results histologically and by ultrasound, and found a 50% and 33% reduction, respectively, in the thickness of the superficial fat.

The mechanism of action for cryolipolysis and how it produces selective apoptosis in adipocytes remains unclear. One possible mechanism is that adipocyte death is caused by reperfusion injury which triggers free radicals, oxidative stress, and ensuing cell death. Under histologic analysis, there are no notable changes immediately after treatment. However, by day 3, an inflammatory process occurs and adipocytes become encircled by histiocytes, neutrophils, and lymphocytes. By 7 days, a lobular panniculitis is noticed. This process peaks at day 14, and between days 14 and 30, macrophages engulf the adipocytes and the inflammation decreases slowly over a 90-day period. Histologically, interlobular septae are thickened, and the fat volume is decreased by 2 to 3 months after treatment. Also, the epidermis, dermis, nerves, blood vessels, and muscles remain unharmed.^{2,4,8}

In 2010, the first cryolipolysis device (CoolSculpting[®], Zeltiq Aesthetics) was approved by the FDA for the reduction of abdominal and flank fat. Since then, its clinical indications have expanded to include fat reduction of the abdomen, flanks, upper arm, brassiere rolls, lumbar rolls, banana roll, thigh, and the submental area in individuals with a body mass index of 30 or less.⁹ During a typical 60-minute session, the area of fat is vacuum suctioned into a cup-shaped applicator which is attached to a central console via an umbilical cable. The console maintains a preset temperature, below 0°C, using sensors implanted in cooling plates on the sides of the applicator. The suction allows for maximum contact with the cooling plates and causes some vasoconstriction, allowing more rapid cooling of the skin.^{2,3}

There have been numerous human clinical trials performed demonstrating the efficacy of cryolipolysis for selective fat reduction. In 2009, Dover et al. performed a trial using cryolipolysis on the flanks of 32 subjects. They assessed improvement using photography, physician assessment, and subject satisfaction.¹² Ten subjects were further assessed by ultrasound of the treatment area. They found that all subjects had a reduction in the fat layer, with an average reduction of 22.4% seen by ultrasound. Another study by Kaminer et al. in 2009, treated 50 subjects with each serving as their own control.¹³ Each patient underwent cryolipolysis treatment of one flank and used photography and three blinded physicians to assess the subjects. The physicians could differentiate with an 82% accuracy rate between the treated and untreated side. The evidence from these two studies led to FDA approval for treatment of the flanks by cryolipolysis. Further studies include those by Sasaki et al., who in 2014 treated six patients in a pilot study and then went on to treat 112 in the clinical treatment group.³ This demonstrated similar findings to previous studies, with an average fat reduction at 6 months of 21.5% by caliper measurements and 19.6% by ultrasound measurements (Fig. 68-1). They also found that massage in one patient after treatment led to more rapidly increased temperatures. In 2015, Ingargiola et al. published a review article evaluating 19 cryolipolysis clinical trials in humans.⁴ They found that average fat reduction ranged from 14.67% to 28.5%, as measured by caliper, and 10.3% to 25.5%, as measured by ultrasound.



Figure 68-1. A 51-year-old female from the pilot study. (A,C) Subject's pretreatment photographs. (B,D) Subject's photographs 6 months after cryolipolysis treatment of her entire lower abdomen with a large applicator in a single session.

Adverse events from cryolipolysis are generally mild, and include erythema, ecchymosis, swelling, sensitivity, and pain. Erythema is most common, occurs immediately, and can last for several hours after treatment (Fig. 68-2).¹¹ Ecchymosis can be observed for days after treatment due to the vacuum suction used during the procedure, and is worse in patients taking anticoagulants.^{2,4} Transient numbness is another finding which was studied by Coleman et al. in 2009.¹⁴ He reported that six out of nine subjects experienced decreased sensation assessed by neurologic evaluation; however, this completely resolved after a mean of 3.6 weeks post-treatment. On biopsy, there were no long-term changes observed in the nerve structure. Another very common complaint is pain. Most subjects experience a “shooting” or “cramping” pain within 1 week post-treatment. This is most likely due to the cold-induced panniculitis, and studies have found a correlation between increased pain and larger surface area treated. Most subjects reported that the pain was tolerable, could be controlled with oral analgesics, and resolved spontaneously over 1 to 4 weeks.^{2,8}

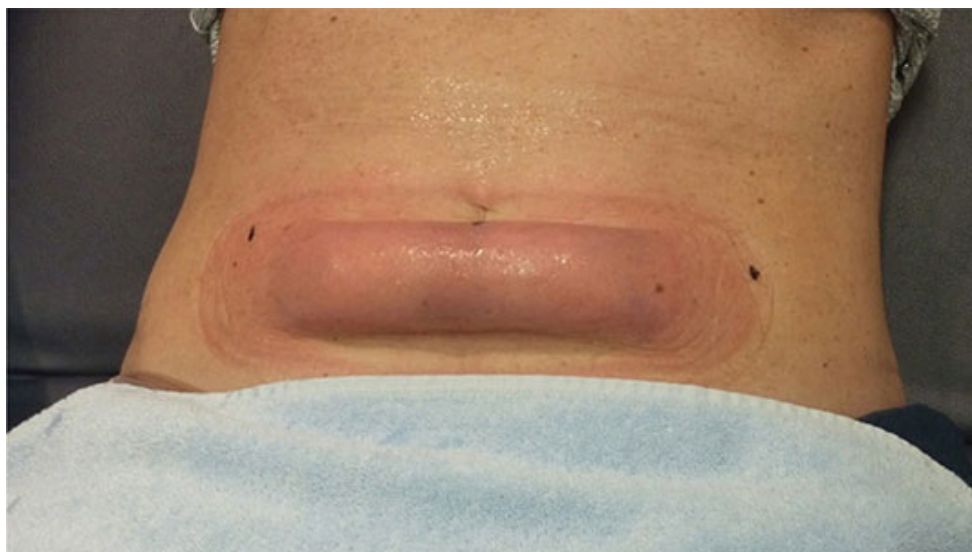


Figure 68-2. “The butter stick” erythema and swelling of the abdomen immediately post-treatment.

In addition, there is a theoretical risk that lipid levels and liver function tests could possibly be increased due to the absorption of adipocytes by macrophages. However, multiple studies evaluating lipid levels and liver function tests (including aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, total bilirubin, and albumin) after treatment found no evidence of a significant increase in levels.^{15–18} One very rare side effect that has been observed is paradoxical adipocyte hyperplasia. This has been reported in 33 cases, and the exact mechanism of action is unknown. No spontaneous resolution has been reported, and the only treatment is liposuction or abdominoplasty.¹⁹ Contraindications to cryolipolysis include cold-induced conditions such as cold urticaria, cryoglobulinemia, and paroxysmal cold hemoglobinuria. It also should not be performed in areas with edema, dermatitis, varicose veins, or other cutaneous conditions.⁴ As far as patient satisfaction, Dierickx et al. performed a study in 2013 that reported 73% of 518 subjects were satisfied with their treatment and 82% would recommend the procedure to a friend.²⁰ In that study, only 6 out of 528 subjects were dissatisfied and 4 out of the 6 were satisfied after a second treatment was performed.

Overall, cryolipolysis has proved to be an effective means of selective noninvasive fat reduction, with the best results seen in individuals close to their ideal body weight. Most people can expect to see an estimated 25% reduction in the fat layer with final results seen 3 months after treatment.

Sometimes, a second treatment can be beneficial for targeting thicker areas, such as the abdomen.²

HIGH-INTENSITY FOCUSED ULTRASOUND

HIFU is another method used for noninvasive fat reduction. Although the device for body contouring was approved in 2011 (LipoSonix[®] by Medicis), HIFU has been used for decades to noninvasively treat kidney stones, epicardial tissue ablation for arrhythmias, destruction of uterine fibroids, and to destroy tumors of various organs. This device was first used in the cosmetic field as an adjunct to liposuction; however, when highly focused, it can be used effectively as a stand-alone procedure.^{2,21} HIFU works by a thermomechanical process in which the acoustic waves are precisely focused on the subcutaneous fat layer, bypassing the overlying epidermis and dermis. This quickly heats the area to a temperature above 56°C to cause a coagulative necrosis of the adipocytes in 1 to 2 seconds. The mechanical action is achieved through microscopic shear forces that generate additional frictional heating. Histologic examination post-treatment identifies adipocyte necrosis immediately after treatment. After 2 weeks, a localized inflammatory response with mostly lipid-laden macrophages can be seen within the treatment area, which completely dissipates by 14 weeks post-treatment when maximum clinical effects can be observed.^{2,22,23}

Jewell et al. performed some of the first clinical trials in 2011 targeting abdominal fat in 26 Yorkshire pigs.²² They found that during treatment, the targeted subcutaneous fat layer approached 70°C with no damage seen histologically to the surrounding tissues, vasculature, or nerve fibers. Microscopic examination showed the accumulation of macrophages at the damaged tissue with no evidence of fat emboli or fat accumulation. No significant changes were seen either in serum lipid levels or liver function tests. Initial clinical studies involving humans were performed by Fatemi et al.^{24,25} In 2009, they published a retrospective case series involving 282 subjects who underwent a single HIFU treatment of their abdomen and flanks. The treatment took approximately 1 to 1.5 hours to perform and resulted in an average waist circumference decrease of 4 to 5 cm.²⁴ Then in 2010, they reported on an additional 85 subjects who underwent a single session of

HIFU to the same treatment areas. They found an average waist circumference decrease of 4.6 cm after 3 months post-treatment.²⁵ Subject satisfaction was found to be greater than 70% 3 months post-treatment in both series. Jewell et al. published another clinical trial in 2011 in which 180 adults (aged 18–65 years) with subcutaneous abdominal fat greater than or equal to 2.5 cm thickness were selected to be in one of three groups in a 1:1:1 randomized fashion.²⁶ There were two treatment groups which differed in energy levels (47 J/cm and 59 J/cm) and one sham-treatment control group which had an energy level of 0 J/cm. After 12 weeks, statistically significantly decreased waist circumference was achieved for both treatment groups compared to the control group, with greater efficacy noticed in the 59 J/cm group (–2.52 cm vs. –2.10 cm in the 47 J/cm group). However, a 1.2-cm decrease was also seen in the sham-treated group at 12 weeks.

Common adverse events are reported in roughly 12% of subjects who have received HIFU and include prolonged tenderness, edema, ecchymosis, and hard lumps. These have been found to spontaneously resolve within 1 to 3 months post-treatment. Some patients also report excessive pain during the process, but this resolves after the procedure is completed.^{2,27} A study by Lee et al. published in 2016 utilized a contact cooling system during the HIFU procedure which appeared to provide a less painful experience without loss of efficacy.²⁷ Further trials exploring adjunctive cooling methods may make the HIFU procedure a more comfortable experience in the future.

LOW-LEVEL LASER THERAPY

LLLT, or cold laser therapy, was first reported by Mester in 1968 when he noticed hair regrowth in mice after exposure to a ruby laser for stimulation of wound healing.²⁸ Since then, LLLT has been used for multiple purposes including pain relief, decreasing inflammation and edema, and regenerating tissue growth.²⁹ In 2002, Neira et al. introduced the concept of using LLLT for fat removal as an adjunct to liposuction.³⁰ Using a 635-nm, 10-mW diode laser, tissue from 12 subjects post-liposuction was collected and irradiated for 0, 2, 4, and 6 minutes. The type of laser chosen was based on previous evidence that wavelengths between 630 and 640 nm were optimal for

biomodulation. Their results showed that at 4 minutes, 80% of the fat was released from adipose cells and at 6 minutes, 99% of the fat had been released. The mechanism of action remains somewhat controversial. In the report by Neira et al., the tissue was examined under an electron microscope and transitory pores were discovered in the cell membrane, presumably caused by the laser. This allowed the lipid content to leave the cell into the interstitial space, resulting in adipocyte deflation. Therefore, unlike other methods of noninvasive fat removal, the adipocyte is not destroyed using LLLT, but decreased in size. The pore is hypothesized to be induced by the photoexcitation of cytochrome-c oxidase, a terminal enzyme within the mitochondria.^{29,30} Other hypothesized mechanisms include the formation of increased reactive oxygen species (ROS), initiating a process known as lipid peroxidation, where ROS causes pores due to reactions with lipids found in the cell membrane. Some report that they do not see microscopic pores and believe that LLLT causes activation of the complement cascade resulting in adipocyte apoptosis followed by the release of lipids. These theories are the subject of active investigation.²⁹

An LLLT device (Zerona[®] by Erchonia) was first approved in 2010 by the FDA for noninvasive selective fat reduction of the waist, hips, and thighs and in 2012, gained approval for fat reduction of the arms. It was the first noninvasive aesthetic device approved by the FDA for circumferential reduction of the waist, hips, and thighs in the United States. The device consists of five low-power laser diode modules (one central unit and four suspended by adjustable arms) which each emit 17 mW of 635-nm laser light. Generally, treatment of an area requires six to eight sessions lasting around 30 minutes each.^{2,29,31}

Multiple studies have been performed assessing LLLT for noninvasive fat reduction. The first study conducted, which helped to gain approval by the FDA for Zerona, was performed by Jackson et al. and published in 2009.³² This double-blind, randomized, placebo-controlled trial evaluated 67 adults assigned to receive either LLLT or matching sham treatments three times a week for 2 weeks. Subjects in the treatment arm demonstrated an average reduction of 0.98 in at the waist, 1.05 in at the hip, and 0.85 and 0.65 in across the right and left thighs, respectively. In 2011, Caruso-Davis et al. used a similar but different device, the LAPEX 2000 LipoLaser System[®] by Meridian, with wavelengths between 635 and 680 nm, to evaluate its

effectiveness for body contouring.³³ With 40 subjects randomized 1:1 into the treatment arm or the control group, treatment occurred for 30 minutes twice a week for 4 weeks. Cumulative circumference loss at the end of 4 weeks was -2.15 cm, showing significant improvement compared to the control group. However, this system has not been approved by the FDA for body contouring and is currently only indicated for pain associated with carpal tunnel syndrome. In 2012, Nestor et al. published a clinical trial in which 40 subjects were randomized 1:1 to a treatment group (Zerona) or a sham treatment group.³⁴ They received treatment sessions three times per week for 2 weeks to the upper arm area. After six treatments, the treatment group showed a combined arm circumference reduction of 3.7 cm versus 0.2 cm in the control group (Fig. 68-3). In 2016, Thornfeldt et al. tested a different treatment protocol, using the Zerona device.³⁵ A total of 54 subjects were treated once weekly with LLLT to the waist, hips, thighs, and abdomen for 6 weeks. Findings showed an average decrease in the combined body circumference of 5.4 in. They compared their data to previous studies using the 2-week protocol consisting of three treatments per week and found that the 6-week method may be more effective. However, there was no control group in this study and the mean BMI of subjects in the 2-week versus the 6-week protocol differed.

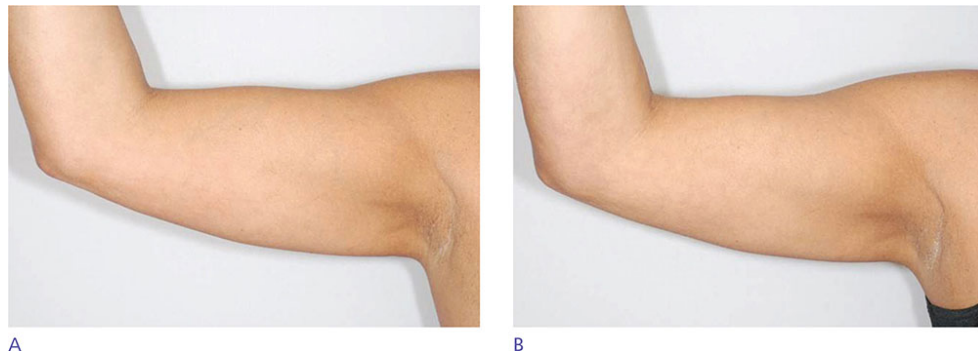


Figure 68-3. (A) Before treatment of the arm. (B) Two weeks post six treatments of LLLT over a 2-week period.

Researchers are investigating other frequencies of LLLT, such as green laser light, for body contouring. Although green laser light has previously been used as an ablative laser in dermatology for tattoo removal, low-level green laser is now being studied for its role in noninvasive fat removal. In 2013, Jackson et al. performed one of the first trials using a green laser

called Verjú[®] by Erchonia.^{36,37} This system was approved by the FDA in 2013 and was the first green laser to use six 532-nm green diodes instead of five 635-nm red diodes typical of other LLLT models. In this double-blind clinical trial, 68 subjects were randomized into either a treatment or sham treatment group to primarily evaluate the reduction in the appearance of cellulite, but also in the combined reduction of thigh circumference. Subjects received six treatments (15 minutes to the anterior abdomen and 15 minutes to the lower back area) over a 2-week period. After 6 weeks, 19 subjects in the treatment group saw reduction in the appearance of cellulite compared to three subjects in the sham-treated group. In addition, a significant decrease was found in the mean combined thigh circumference at 6 weeks (44.77 in) compared to baseline measurements (47.13 in). Since then, two other studies have been performed testing the efficacy of the Verjú laser for fat reduction. In 2014, Suarez et al. conducted a similar study using 67 subjects randomized to receive six treatments or sham treatments over a 2-week period.³⁸ After 2 weeks, the total mean combined circumference measurements decreased by 3.9 in over the waist, hips, and upper abdomen in the treatment group versus 1.1 in for the sham-treated group. Likewise in 2016, Roche et al. randomized 53 obese subjects (BMI between 30 and 40 kg/m²) into either a treatment or sham treatment group to receive thrice-weekly treatments over a 4-week period.³⁹ After 4 weeks, 71.43% of subjects in the LLLT group achieved ≥ 7.2 cm decrease in combined measurements over the hip, waist, and upper abdomen compared to three subjects in the sham-treated group. In addition, the mean decrease in combined measurements for the LLLT group was 10.52 cm versus 1.80 cm in the sham-treated group.

LLLT appears to be not only an effective means for fat reduction, but also a very safe alternative. There have been no adverse events reported to date, and results can be seen sooner—within 2 weeks—compared to other methods of noninvasive body contouring.^{31,34–36,38,39}

HYPERTHERMIC LASERS, RADIOFREQUENCY, AND INFRARED LASERS

Other modalities to achieve noninvasive body contouring are continuing to be explored. In 2015, a hyperthermic laser (SculpSure[®] by Cynosure) was approved by the FDA for noninvasive fat removal. It is a 1,060-nm diode laser that heats the subcutaneous adipose tissue to a temperature between 42° and 47°C. This causes destruction of adipocytes which are later reabsorbed by the lymphatic system. The epidermis and dermis are spared due to a contact cooling system which is used during the typical 25-minute procedure. In 2017, Decorato et al. published a study using the SculpSure device.⁴⁰ They enrolled 17 subjects and performed a single session on either their abdomen or flank. The only side effects observed were mild pain, stinging, and numbness, which all resolved by 2 weeks. After 12 weeks, with the aid of photographs, ultrasound, and MRI, they found overall fat reduction similar to results using cryolipolysis (24%).

RF waves provide another approach to noninvasive fat reduction. When RF waves irradiate tissue, they generate an oscillating electrical field which generates an electrical current. This current causes collisions between charged molecules and ions generating molecular friction which is then transformed into heat. When targeted at adipose tissue, RF destroys fat by causing apoptosis within the cells. Skin and muscle have different conductivity and relative permittivity than fat, which allows for fat to be selectively targeted without destroying the overlying epidermis, dermis, and surrounding tissues. RF has been FDA approved for reduction in the appearance of cellulite, skin tightening, and for circumference reduction when paired with infrared light and suctioning.^{31,41}

Infrared lasers, using infrared vibrational absorption bands, also work by heating adipose tissue. Selective photothermolysis is the mechanism of choosing a specific wavelength of light and pulse duration to target a tissue without impairing the surrounding structures.² In 2006, Anderson et al. found that the absorption peaks of lipids were at 1,210 and 1,720 nm. This is where the absorption of lipids is greater than that of water, allowing targeting of the fat layer without damage to the overlying skin.⁴² In 2009, a human pilot study was conducted by Wanner et al. exploring the effectiveness of a 1,210-nm laser using a 10-mm spot size with a 3-second exposure time on the abdomen of 24 adults.⁴³ After the treatment, punch biopsies were taken at 1 to 3 days or 4 to 6 weeks later. Results showed dose-dependent damage to the subcutaneous fat and dermis. Subjects also reported that the treatment was

painful, though it was well tolerated in most subjects. Although significant results were observed, there has not been evidence to support treating larger surface areas. The ability to target the reticular dermis may provide a future role for the treatment of cellulite by infrared lasers.

These two modalities have been combined to provide more effective results. Adatto et al. in 2014 published a study looking at the effectiveness of a device (Velashape[®], Syneron Medical Ltd.) that incorporates four treatment modalities including bipolar RF, infrared light, pulsed vacuum, and mechanical massage.⁴⁴ This device is indicated to not only reduce fat, but also to cause skin tightening. Throughout the study, 35 subjects received once-weekly treatment to their abdomen, flank, buttock, or thigh area for 6 weeks, and were followed for up to 3 months post-treatment. At 3 months, subjects showed an average reduction of 1.4, 0.5, and 1.2 cm to their abdomen/flank, buttocks, and thighs, respectively, compared to baseline. Combining modalities like these in future studies may provide enhanced efficacy of current treatments.

CONCLUSIONS

Noninvasive fat removal has come a long way in the past decade. This rise in rapid, largely painless, and effective procedures has expanded the cosmetic field of body contouring. Still, head-to-head studies have not been conducted to directly compare the effectiveness of different modalities. Further studies are needed to better delineate the ideal treatment approach, though to date all minimally invasive body-contouring technologies fall far short of liposuction in terms of clinical efficacy and rapidity of response.

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CHAPTER 69 Laser- and Light-Based Approaches to Hair Loss

Sejal Shah
Gian L. Vinelli



SUMMARY

- Hair loss is a common problem, ultimately affecting at least half of all men and women.
- While medical therapy is the mainstay approach, other interventional options such as hair transplantation are increasingly popular.

- Low-level laser and light therapy show some promise for hair loss treatment, though large comparative nonindustry sponsored trials are lacking.

Beginner Tips



- Patients should understand that the degree of improvement seen with LLLT may be modest.
- Frequent treatments may be necessary to see a meaningful response.
- Patients should appreciate the distinction between a statistically significant improvement and a clinically significant improvement.

Expert Tips



- Given the availability of relatively low-cost LED arrays, many patients now choose to attempt treatment using home-based devices.
- In-office laser or LED-based devices remain an option, and patients should be aware of the need for frequent treatments.

Don't Forget!



- While in theory low-energy settings on existing devices may be used to treat hair loss, care should be taken to keep settings low enough so as not to cause hair loss.

Pitfalls and Cautions



- Though hair counts may increase with LLLT treatment, it is not clear whether the clinical impact of therapy is sufficient to be meaningful to patients. Therefore, medical and transplant approaches should probably be considered the first line treatment for hair loss.

Patient Education Points



- Many treatments will be required, and the degree of improvement in hair loss may be modest.
- LLLT can best be conceptualized as an adjunct approach to hair loss management.

Billing Pearls



- Almost all insurers in the United States exclude laser- and light-based treatments from coverage.
- Patients may benefit from committing to a series of treatments, as this may allow significant cost savings.
- Alternatively, many patients are opting for home-based units, as the one-time cost of purchase is significantly less than the cost of repeated treatments in a physician's office.

CHAPTER 69 Laser- and Light-Based Approaches to Hair Loss

INTRODUCTION

Alopecia is a common disorder, and androgenetic alopecia (AGA) is the most common form of hair loss in both men and women, with half of men over 50 and half of women over 80 affected. AGA is likely the product of a genetic predisposition (as revealed by high concordance rates among monozygotic twins) coupled with androgen hypersensitivity. The effect of testosterone and dihydrotestosterone on hair follicles has been thoroughly elucidated. With progression of AGA, both the proliferation of follicles and the period of time follicles are in anagen decrease, resulting in miniaturization of the hair follicle and conversion of terminal hairs into vellus hairs.

Hair loss can be detrimental to both the mental health and quality of life of patients. This is especially true of women, due largely to societal norms and expectations. Scalp hair is central to not only one's identity, but also defines the perception of what is attractive for both men and women.

Despite the widespread prevalence of AGA, there are few treatment options. The current mainstay of therapy is topical minoxidil and oral finasteride. However, both treatments have limitations, with poor response in younger patients, requirement of lifelong treatment to maintain results, and a risk of birth defects in women. Moreover, finasteride is associated with adverse sexual side effects (decreased libido, ejaculate volume, and erectile

dysfunction). Finally, in many patients these treatments may halt further hair thinning (Fig. 69-1), rather than provide significant hair regrowth. Hair transplant surgery is an alternative treatment, but has its limitations as well. Due to these limited options, investigations into other treatment options, including platelet rich plasma, topical prostaglandins, anti-androgens, and laser- and light-based therapies, have emerged.



Figure 69-1. Female patient at baseline (A). Note the pronounced hair thinning. After treatment with low-level light therapy the patient saw significant improvement (B). (Used with permission from HairMax).

BACKGROUND

The physician, Endre Mester of Hungary, was the first to report hair growth stimulated by a laser. In 1967, he conducted experiments with a low-power ruby laser (694 nm) to evaluate its carcinogenicity on the shaven backs of mice. To his surprise, not only was cancer not seen, but there was improved wound healing and hair growth. He continued to use low-power lasers, which lack a tissue damaging photothermal effect seen in high-power lasers, to treat nonhealing ulcers.¹

More recently, paradoxical hair growth has been reported in some patients undergoing laser hair removal. Together, these findings have suggested a regenerative effect of low-level laser therapy (LLLT).²⁻⁹ Thermal energy generated during laser hair removal typically results in epilation of the hair. However, at suboptimal fluences, rather than epilate the hair, hair growth has been observed. In these cases, an increase in hair density, color, coarseness and/or thickness has been noted. This phenomenon is known as “paradoxical hypertrichosis,” and its incidence varies from

0.6% to 10%.¹⁰ Numerous explanations have been put forth to explain paradoxical hypertrichosis. One such mechanism is that the heat generated during laser therapy results in increasing levels of heat shock proteins (HSPs), which are involved in cell growth and differentiation.¹⁰ Moreno-Arias et al. attributed it to the presence of polycystic ovarian syndrome.² Another proposed mechanism involves the generation signaling factors from subtherapeutic thermal injury which then induce follicular proliferation and angiogenesis.¹¹

LLLT involves laser therapy in the wavelengths of 632 to 1,064 with 1 to 1,000 mW of power. LLLT has recently shifted from the lasers to the use of light-emitting diodes (LEDs) as a light source. LEDs produce light in similar wavelengths to the original lasers, but lack the coherence of laser light and are less monochromatic. Moreover, they are significantly less expensive, leading to development of cheaper devices for the public. Currently there are companies marketing devices for personal use and at aesthetic salons and physician practices.

PROPOSED MECHANISMS

LLLT is thought to promote entry of telogen follicles into anagen, prolong duration of anagen, increase rates of proliferation of anagen follicles, and prevent premature catagen development.^{10,12} However, the exact mechanism by which LLLT affords these changes is not well established.

LLLT triggers a photochemical reaction, also known as biostimulation or photobiomodulation. When a chromophore within the cell absorbs the light, an electron within the chromophore moves from a lower-energy orbit to a higher-energy orbit. This energy can be used to perform various cellular tasks. There is strong evidence that shows that the target of LLLT is a chromophore within the mitochondria, primarily cytochrome c oxidase (CCO), complex IV in the respiratory chain of mitochondria. LLLT is thought to release inhibitory nitric oxide (NO) from COO thereby increasing adenosine triphosphate (ATP) production. Additionally, LLLT modulates reactive oxygen species (ROS). These changes in turn activate transcription factors, which leads to the expression of various protective and stimulatory genes. These genes are involved in downstream effects such as increasing cell proliferation and migration and modifying levels of cytokines, growth

factors, and inflammatory mediators. LLLT has also been shown to cause vasodilation, likely via NO, resulting in increased blood flow and nutrient and oxygen delivery to the areas treated.¹³ All of these effects potentially play a role in hair growth.

Weiss et al. found that LLLT can potentially affect the expression of 5- α reductase, vascular endothelial growth factor (VEGF), and matrix metalloproteinase 2 (MMP-2), all of which play a role in hair follicle growth. Additionally, the group noted hair growth on human dermal papilla cells.^{14,15}

Similarities between the mechanism of action of LLLT and minoxidil have been noted. Like LLLT, the exact mechanism of action of minoxidil is not fully understood; however, it is known that minoxidil may lead to release of NO and is a vasodilator. Minoxidil is also an ATP-sensitive K⁺ channel mediator.

CLINICAL EFFECTIVENESS

A number of in vitro, ex vivo, animal and human studies have demonstrated the efficacy of laser and light therapy for hair growth (Tables 69-1 and 69-2).

Table 69-1. Summary of Animal Studies

Author, year	Subject	Alopecia Type	Device Type	Treatment Regimen	Assessed Parameters	Effectiveness
Chung et al., 2004	C57BU6 Black mice	Hair removed by electric razor and hair remover cream	Diode laser system	890 nm, dose of 1.8 J/cm ²	Clinical examination and histology	Yes
Shukla et al., 2010	Swiss albino mice	Testosterone treated mice	Helium–neon laser	632.8 nm, dose of 1 and 5 J/cm ² at 24 hour intervals for 5 days	Histology and optical coherence tomography	1 J/cm ² was effective
Fushimi et al., 2011	Female BL-6 mice	Shaved off	Narrow band red LED light	638 nm, dose of 1 J/cm ² $\times$ 20 minutes every second or third day	Clinical examination	Yes, compared to sham-treatment group
Wikramanayake et al., 2012	C3H/HeJ mice	Heat-induced alopecia areata	HairMax LaserComb	655 nm, 20 seconds 3 $\times$ per week for 6 weeks	Clinical examination and histology	Yes, compared to sham-treatment group
Wikramanayake et al., 2013	Rat model	Chemotherapy-induced alopecia	HairMax LaserComb	655 nm, 1 minute daily $\times$ 10 days	Clinical examination and histology	Yes, compared to sham-treatment group
Olivieri et al., 2014	Dogs	Canine non-inflammatory alopecia	BTL 4000-therapeutic laser	470 nm, 685 nm, and 830 nm, 3 J/cm ² 2 $\times$ per week up to 2 months	Clinical examination and histology	Yes
King et al., 2014	C3H/HeJ female mice	Spontaneous or graft-induced alopecia areata	HairMax LaserComb	655 nm, 20 seconds 3 $\times$ per week for 6–12 weeks	Clinical examination and histology	Not effective

Table 69-2. Summary of Human Studies

Author, year	Total Patients, Alopecia Type	Device Type	Treatment Regimen	Assessed Parameters	Effectiveness
Satino et al., 2003	35 (28 m., 7 f.), MPHL, FPHL	Hair-Max Laser Comb	655 nm, 5–10 minutes every other day for 6 months	Hair count and VIP HairO-Scope for tensile strength	Yes, in both sexes
Yamazaki et al., 2003	15 (6 m., 9 f.), AA	Super Lizer	High output (1.8W), infrared radiation (600–1600 nm), 3 minutes once every week or every 2 weeks until vellus hair regrowth in at least 50% of affected area	Hair regrowth (method is unclear)	Yes
Waiz et al., 2006	16 (11 m., 5 f.), AA	Pulsed infrared diode laser	Four-session basis, once a week, 904 nm at a pulse rate of 40%, 1.2 mW	Hair regrowth observation	Yes
Kim SS et al., 2007	24 m., MPHL	Portable light source	655-nm red light and 780 nm infrared light once a day for 10 minutes for 14 weeks	Hair density, patient satisfaction	Yes
Avram et al., 2009	7 (1 m., 6 f.), MPHL, FPHL	Laser Hood	650 nm, 5 mW twice weekly for 20 minutes each time over a period of 3–6 months	Hair count	No significant changes
Leavitt et al., 2009	110 m., MPHL	HairMax LaserComb	655 nm, 3× per week for 15 minutes on non-concurrent days for 26 weeks	Computer-aided hair count, subject assessment	Yes compared to sham-treated arm
Rushton et al., 2012	2 m., MPHL	HairMax LaserComb	7.5 minutes for 3 days (Monday/Wednesday/Friday) each for 26 weeks	Unit area trichogram, contrast-enhanced phototrichogram	No improvement
Kim et al., 2013	40 (26 m., 14 f.), MPHL, FPHL	Helmet-type device	630-, 650-, and 660-nm LEDs, 18 minutes daily for 24 weeks; mean energies per unit 3.4 mW for 630-nm LED, 2.5 mW for 660-nm LED, and 4.1 mW for LD	Hair density, investigator global assessment, subject global assessment	Yes compared to sham-treated arm, no significance in subject global assessment
Lanzafame et al., 2013	44 m. MPHL	TOPHAT655	21 5-mW lasers (655 ± 5 nm) and 20 LEDs (655 ± 20 nm), every other day × 16 weeks (60 treatments, 67.3 J/cm ² irradiance/25 minutes)	Hair count	Yes compared to placebo group
Munck et al., 2014	32 (11 m., 21 f.), MPHL, FPHL	HairMax LaserComb	655 nm 3× weekly between 8 and 15 minutes	Hair growth observation	Yes
Lanzafame et al., 2014	47 f., FPHL	TOPHAT655	21 5-mW lasers (655 ± 5 nm) and 20 LEDs (655 ± 20 nm), every other day × 16 weeks (60 treatments, 67.3 J/cm ² irradiance/25 minutes)	Hair count	Yes compared to placebo group
Jimenez et al., 2014	269 (128 m., 141 f.), MPHL, FPHL	HairMax LaserComb	7-beam (655 nm, 15 minutes), 9-beam (655 nm, 11 minutes), 12-beam dual model emits 6 beams (635 nm, 8 minutes), 6 beams (655 nm), 3× per week on entire scalp, 26 weeks	Hair density, patients' self-assessment	Yes compared to sham-treated groups

In an ex vivo study, Leavitt evaluated the effects of a 635- and 660-nm laser on hair growth, and observed a significant increase in the rate of hair growth of hair follicles treated with LLLT compared to control hair follicles (Fig. 69-2).¹⁶ Similarly, Hamblin found that LLLT increased hair growth compared to a control in another study.¹⁷



Figure 69-2. Macro view of hair follicles before and after treatment. (Used with permission from HairMax).

Animal studies have shown a positive effect of LLLT on different types of alopecia, including alopecia areata (AA) and chemotherapy-induced alopecia (CIA). Shukla et al. compared the effects of a helium-neon laser

(632 nm) at doses of 1 J/cm² and 5 J/cm² on the hair follicle growth cycle of testosterone treated and untreated Swiss albino mice. Exposure to the lower dose resulted in a significant increase in the number of anagen hair follicles in the testosterone-treated mice compared to the other groups. Treatment with the higher dose resulted in a significant decrease in the number of anagen hair follicles and an increase in the number of telogen hair follicles. This finding is consistent with the biphasic effect of LLLT, where low doses cause biostimulation and high doses cause inhibition. Wikramanayake et al. studied the effects of LLLT on a CH3/HeJ mouse model of AA. The HairMax LaserComb 655 nm was used for 20 seconds 3 times per week for a total of 6 weeks. At the end of the treatment period, regrowth was observed in all the mice treated with laser device but no change was observed in the sham-treated group. Histologic examination found an increase in the number of anagen follicles in the treated mice compared to telogen follicles without hair shafts in the untreated mice.¹⁰ This is contrary to the results of a study by King et al. which did not find a positive response to LLLT in a CH3/HeJ mouse model of AA. However, this difference could be due to differences in the study model. LLLT was also found to accelerate hair growth in a rat model of CIA.¹⁸

Human studies have examined LLLT for the treatment of AGA and AA in both men and women. Satino et al. studied the efficacy of the HairMax LaserComb 655 nm for the treatment of AGA in both men and women. Participants were asked to use the device every other day for 6 months. At the end of the treatment period, a substantial improvement was found in both hair counts and tensile strength, with the vertex area in men showing the best improvement. In a 26-week double-blind sham device-controlled randomized trial in which 110 men with AGA were treated with either the HairMax LaserComb or a sham device, Leavitt et al. found that subjects in the treatment group exhibited a statistically significant increase in mean terminal hair density compared to those in the sham device group. Based on the patients' assessment, the patients in the treatment group reported greater improvement in overall hair regrowth, decreased hair loss, thicker feeling hair, better scalp health and hair shine compared to the patients treated with the sham device. This randomized controlled trial (RCT) led to FDA clearance for the HairMax LaserComb.

In a small study published by Avram and Rogers, seven subjects (six females and one male) with AGA were treated with an LLLT hood device

(650 nm) twice a week for a total of 3 months (five subjects) or 6 months (two subjects). On average, subjects had a decrease in vellus hair, increase in terminal hairs, and an increase in hair shaft diameter at 3 months.

However, these changes were not statistically significant.¹⁹ Munck et al. evaluated the HairMax LaserComb in a retrospective study over a 24-month observational period. The study included both men and women with AGA using the HairMax LaserComb as either monotherapy or combination therapy. Patients in the concomitant treatment group had been using topical minoxidil or oral finasteride for at least 9 months before starting LLLT. Based on global photographic assessment, 8 patients (25%, 3 females and 5 males) experienced significant improvement, 20 patients (63%, 14 females and 6 males) moderate improvement, and 4 patients (12%, 4 females and 0 males) saw no improvement. The first RCT that evaluated LLLT for the treatment of AGA in both men and women was published by Kim et al. in 2013. Forty subjects (14 females and 26 males) were treated with a helmet-type LLLT device emitting 630-, 650-, and 660-nm LEDs or a sham device daily for 18 minutes. After 24 weeks of treatment, there was a statistically significant improvement in mean hair shaft diameter and hair density compared to the control, although there was not a significant difference in global images between the two groups.²⁰ In another double-blind RCT, Lanzafame et al. looked at the treatment of AGA in males with a helmet style 655-nm LLLT device. Forty-four subjects used the device every other day for 16 weeks. Subjects in the treatment group experienced a 35% increase in hair counts compared to subjects in the control group.²¹ In a subsequent double-blind RCT, Lanzafame et al. evaluated LLLT for the treatment of FPHL. Forty-seven females were treated every other day with a helmet style 655-nm LLLT device for a total of 16 weeks. At the end of the treatment period, subjects in the treatment group had a 37% increase in hair growth compared to the control group.²² Jimenez et al. conducted a 26-week double-blind RCT to determine the efficacy of the HairMax LaserComb in both males and females with AGA. 128 males and 141 females were treated with either a HairMax LaserComb, either 7-, 9-, or 12-beam, or a sham device. The treatment times were adjusted for the various LaserCombs used so that the laser dose rates were similar. A statistically significant increase in terminal hair density was noted in the subjects treated with the LaserComb compared to those treated with the sham device. Based on subjective assessment, a higher percentage

of subjects treated with LaserComb reported overall improvement of hair loss condition and thickness and fullness of hair.²³

Kim et al. evaluated a 655-nm red light and a 780-nm infrared light for the treatment of AGA in 24 males. After daily treatment for 14 weeks, a statistically significant increase in density and increase in the anagen to telogen ratio was noted on both the vertex and occiput (Fig. 69-3).

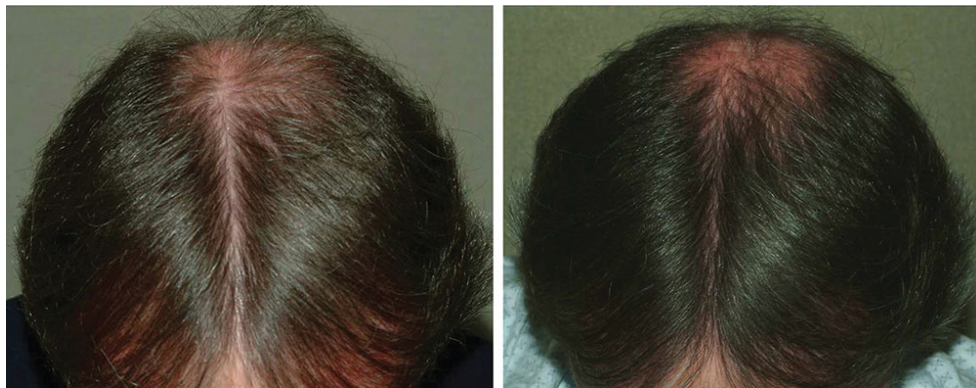


Figure 69-3. Male patient before and after treatment. (Used with permission from HairMax).

SAFETY AND ADVERSE EVENTS

LLLT has demonstrated an exceptionally low incidence of adverse effects. Reported adverse effects include headaches, skin pain and burning, pruritus, erythema, acne, and mild paresthesia. With regard to hair loss, only one study has documented telogen effluvium, which resolved within 2 months with continued treatment and was thought to be due to an accelerated hair cycle in general.²⁴ Because LLLT has proliferative effects, one potential adverse effect is malignant transformation of lesions or the development of de novo malignant lesions. High-dose treatment with LLLT has been shown to significantly increase melanoma growth in a mouse model.²⁵ In human clinical studies, only one case of skin cancer (basal cell carcinoma) has been reported, and the authors felt it was unlikely related to LLLT.¹⁹

DEVICES

Currently, there are a variety of devices available on the market, for both home and in-office use. For home use there are handheld “combs” and cap and helmet devices that can be placed on the head. In-office devices are configured like a hood, which the patient sits under. Some, but not all, of the devices have FDA clearance for hair loss. The use of each device varies, but typically requires two to three sessions per week, anywhere from 90 seconds up to 20 minutes depending on the device (Table 69-3).

Table 69-3. Laser- and Light-Based Devices Available for Hair Growth

Device	Recommended Use	FDA Clearance	Other
Capillus	30-minute session 3× per week	Yes	Three models available
iRestore Laser	25-minute session every other day	Yes	
Hairmax Laserband 82	90-second session 3× per week	Yes	
Hairmax Laserband 41	3-minute session 3× per week	Yes	
Hairmax Ultima 12 Lasercomb	8-minute session 3× per week	Yes	
Hairmax Prima 7 Lasercomb	15-minute session 3× per week	Yes	
iGrow	20–25 minute session 3–4× per week	Yes	
Theradome LH80 PRO	20-minute session 2× per week	Yes	
LaserCap LCPRO	36-minute session every other day	Yes	
Professional Laser Hair Growth System	25-minute session 3× per week	Yes	
Revage 670	Protocols vary. Common protocol: 30-minute session 2× per week for 12 weeks then 30-minute session 1× per week for maintenance	Yes	In-office treatment

CONCLUSIONS

LLLT for hair growth was discovered by chance when mice irradiated with a ruby laser (694 nm) at a low fluence exhibited hair growth on a shaved area of the back. Since then, animal and human studies have confirmed these findings, and it has been shown to be modestly beneficial for a variety of nonscarring alopecias. Furthermore, animal studies have also suggested that it may have benefits in the immediate period after hair transplant surgery for both wound healing and enhancing the viability of the grafts. The exact mechanism of action remains unclear, and further studies are warranted to optimize treatment parameters, determine long-term efficacy, and compare the efficacy of different light sources, as well as other wavelengths that have been associated with paradoxical hair growth, such as 755 nm and 810 nm.^{26,27}

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CHAPTER 70 Photodynamic Therapy for Acne, Actinic Keratoses, and Nonmelanoma Skin Cancer

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SUMMARY

- PDT combines the use of a photosensitizer, a light source within the absorption spectrum of the photosensitizer, and molecular oxygen which, when stimulated, destroys a specific target tissue.
- PDT is a common procedure, and is used for the treatment of actinic keratoses, superficial nonmelanoma skin cancers, acne, and photodamage, among other indications.

Beginner Tips



- While both ALA and MAL are effective photosensitizers for PDT, currently only ALA is available in the United States.
- The ideal time from ALA application to activation ranges broadly, and while the FDA-approved indication calls for ALA application the day before activation, in practice many clinicians wait only 1 hour prior to light activation.

Expert Tips



- Daylight PDT is becoming increasingly popular due to both convenience and comfort, though further studies are needed to better quantify the amount of exposure needed for different geographic locations and different times of the year.

- Both blue LED and IPL have been used with significant success for activation.

Don't Forget!



- Sun protection, including indirect sun protection, is absolutely critical to avoid overactivating the photosensitizer.
- Consider HSV prophylaxis in all patients with a history of HSV in the treated area.

Pitfalls and Cautions



- Stripping may occur due to uneven light or photosensitizer application, and can be treated by retreating the entire area.
- In the United States, PDT is generally not used for the treatment of skin cancers as monotherapy.

Patient Education Points



- Patients should be warned that they will need to not only practice religious sun protection, but that they will also have significant erythema for at least several days after the procedure. Work and social schedules should be planned accordingly.

Billing Pearls



- Insurance coverage for PDT is variable, and generally the only indication for coverage in the United States is nonhypertrophic actinic keratoses on the face and scalp.
- ALA is currently only available from a single manufacturer in the United States and in single-use stick form.
- Since physicians bill directly for the photosensitizing drug, extreme caution is warranted in assuring the amount of coverage available for a given insurance company, as the physician risks spending more on purchasing the medication than they will be reimbursed.

CHAPTER 70 Photodynamic Therapy for Acne, Actinic Keratoses, and Nonmelanoma Skin Cancer

INTRODUCTION

Photodynamic therapy (PDT) was first performed over 3,000 years ago in ancient Egypt, when plant substances in concert with sun exposure were found to produce a skin reaction. PDT represents a chemical reaction, where a photosensitizing chemical (photosensitizer) is activated by a light source in target tissue. The chemical reaction produces singlet oxygen and other cytotoxic free radicals. PDT combines the use of a photosensitizer, a light source within the absorption spectrum of the photosensitizer, and molecular oxygen which, when stimulated, will destroy a specific target tissue.

HISTORY

Modern PDT was initially described by Raab in the early 1900s, who highlighted the phototoxic effects of natural dyes.¹ Later, Jesionek and Von Tappeiner used eosin dye to successfully treat skin cancer.² In the early

1960s, Lipson and Schwartz injected hematoporphyrins into neoplastic tissue and demonstrated fluorescence in tumors.^{3,4}

PDT has been used in the field of oncology, where porfimer sodium injected as an IV infusion has been used for esophageal and nonsmall cell lung cancer,^{5,6} and was the first photosensitizer for PDT to gain approval for human use. Its photosensitizing properties allowed tumors to be illuminated in the gastrointestinal, genitourinary, and pulmonary tracts, as well as skin, to help surgeons better localize neoplasms,⁷⁻⁹ though it was also noted to lead to severe cutaneous photosensitivity for weeks after treatment. An IV infusion PDT procedure using the photosensitizer verteporfin has also been used in ophthalmology to treat the wet form of macular degeneration, which causes central serous retinopathy.¹⁰

One of the noted side effects of the early photosensitizers was that actinic keratoses (AKs) were activated by porfimer sodium. Later, a topically applied PDT procedure was developed with the photosensitizer 5-aminolevulinic acid (ALA).¹¹ PDT was approved in the United States in the late 1990s for nonhyperkeratotic AKs of the face and scalp.¹² PDT has subsequently been used to treat a wide variety of cutaneous conditions, from acne to hidradenitis to cosmetic conditions.

SCIENCE OF PDT

Cutaneous photosensitizers

US FDA-approved photosensitizers include 5-ALA and methyl aminolevulinate (MAL), used to treat AKs. MAL is not currently on the market in the United States, while ALA is absorbed preferentially by actinically damaged skin, skin cancers, and pilosebaceous glands. ALA acts as a prodrug, and penetrates the stratum corneum and becomes localized in target tissue.¹³

Mechanism of action

ALA itself is not a photosensitizer, but after penetrating into the underlying tissue it is converted to protoporphyrin IX (PpIX), a photosensitive

compound.¹⁴ A source that emits light at wavelengths within the PpIX absorption spectrum (spectrum peaks: 409, 509, 544, 584, 634, 636, 708 nm) is then exposed to the treated skin. Since all absorption spectrum peaks are >400 nm (i.e., no longer in the UV spectrum), light exposure itself is not carcinogenic (Fig. 70-1).

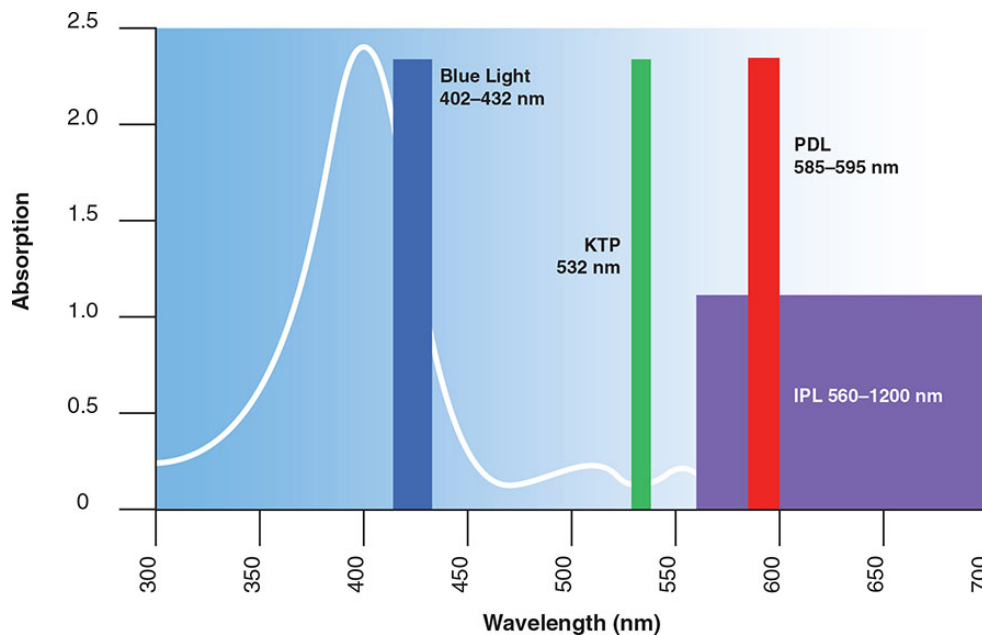


Figure 70-1. Protoporphyrin IX absorption spectrum in vivo for photodynamic therapy.

The ideal time between ALA administration and light activation has been studied, with suggested ranges between 30 minutes and 24 hours. Penetration is proportional to the wavelength of light used for activation, so the longer the light source wavelength, the deeper it penetrates into tissue. Light around 630 nm penetrates to a depth of 5 mm, whereas longer wavelengths of 700 to 800 nm may penetrate as deep as 2 cm. However, with increasing depth there is decreased energy transmitted, and so longer wavelengths lead to a lesser activation of PpIX into toxic metabolites (Fig. 70-2).

TOPICAL PHOTODYNAMIC THERAPY

The Generation of Singlet Oxygen
Using Drugs and Light

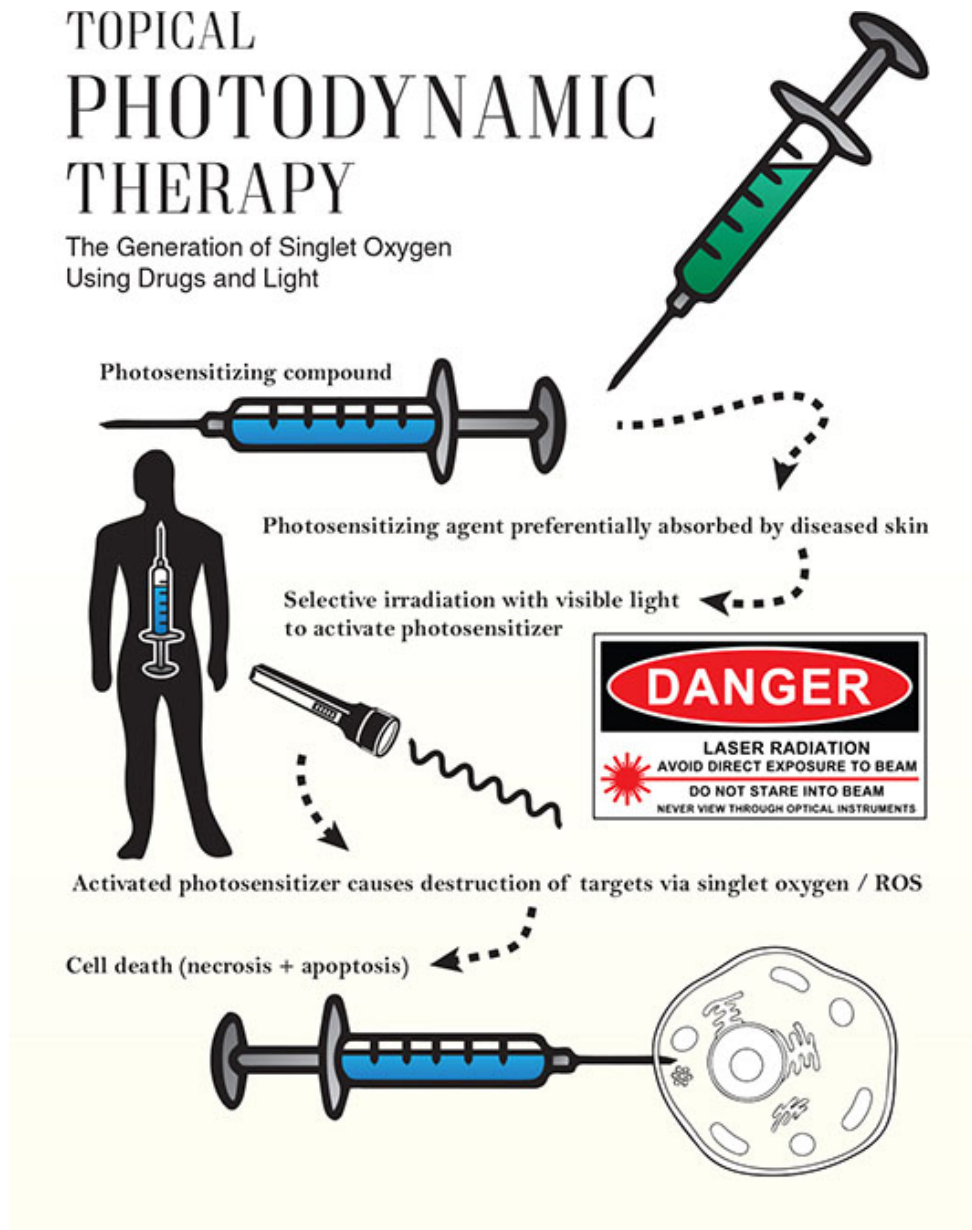


Figure 70-2. PDT leads to apoptosis.

PDT PROCEDURE

Pretreatment considerations

Preprocedure consultation is critical, including a detailed history regarding underlying conditions that may be exacerbated by light, photosensitizing medications, history of herpes simplex virus (HSV), methicillin-resistant

Staphylococcus aureus (MRSA), and whether the patient will be able to modify their lifestyle to accommodate the amount of downtime needed postprocedure (Fig. 70-3).



Figure 70-3. Necessary equipment, including safety eye protection, a timer, and ALA.

Preprocedure, the area is cleansed well with an acetone scrub. In the United States, ALA is sold as a stick applicator for single use. The applicator tip is affixed to plastic tubing which contains one vial of ALA in powder form, and one vial of ethanol solvent. When ready to use, the glass vials are broken with light pressure, and the contents are mixed by rotating the stick back and forth for a recommended 3 minutes. The ALA solution must be used immediately following preparation to avoid instability of the activated product. The dry applicator tip should be dabbed on a gauze pad

until uniformly wet with solution. Apply the solution directly to the target area by dabbing gently with the wet applicator tip. Two passes are recommended to ensure even ALA application to treatment areas. After application is complete, the area may be covered with plastic wrap to prevent ALA evaporation. Occlusive plastic wrap is very helpful during the incubation time period for optimal efficacy.

ALA is incubated on the treatment area for a predetermined time, and the patient is reminded to avoid sun exposure during incubation. This includes indirect sun exposure, so the patient should stay away from windows and remain indoors to prevent premature activation. The conversion of ALA into PpIX is heat dependent, and thus optimal room temperature during incubation of ALA is in a heated room at 80° to 83°F. This may not always be feasible, though electric space heaters may be used and can be monitored via a digital thermometer.

Light and laser selection

The effective light dose depends on the quantity of delivered light and the extent that it includes wavelengths that are absorbed by PpIX. Significant PpIX absorption bands are around 410, 505, 540, 580, and 635 nm. The Soret band absorption at 410 nm is up to 15- to 30-fold greater than the longer wavelengths. Both laser and nonlaser light sources have been used with success in PDT.¹⁵ The light sources that have been studied include incoherent light sources such as halogen/tungsten, xenon, and LED light sources, as well as lasers such as argon dye (630 nm), excimer (630 nm), pulsed-dye laser (PDL, 595 nm), and intense pulsed light (IPL) devices.

Blue light, with a spectral output at 417 nm, has 40× greater potency than red light in activating ALA, though its depth of penetration is more modest. Augmenting penetration with other lasers pretreatment may result in greater efficacy and downtime.

The FDA-approved protocol uses 20% ALA solution without occlusion to nonhypertrophic AKs on the face and scalp with a 14- to 18-hour delay between application of ALA and blue light exposure. Pain from ALA–PDT is proportional to the PDT dose rate, and may be mediated by direct injury to cutaneous nerves. To mitigate this pain, incubation times as low as 1 hour have been suggested and have demonstrated acceptable efficacy.^{16,17}

Other frequently utilized approaches include IPL, which has been used for AK and photoaging with a clearance rate of 50% to 90%. Additionally, PDL is also very effective at PDT activation, using a 100-mm spot size, fluence of 7.5 J/cm^2 , pulse duration of 10 to 20 ms, and double pulsed. Finally, 635-nm LED light sources may be used with an exposure time of 10 minutes.

Laser-assisted drug delivery

The effectiveness of ALA is contingent on how deeply and selectively it penetrates the skin. ALA penetration is influenced by baseline skin thickness and lesion type (deeper penetration with AKs, sun damage, abrasions, and inflammation). Thicker lesions are more resistant to PDT due to the limited depth of penetration of topical photosensitizers. A study by Sandberg et al. revealed that both ALA and MAL often fail to penetrate to tissue depths greater than 1 mm, in part due to the polar and hydrophilic nature of these compounds.¹⁸

Curettage and laser-assisted drug delivery have been explored to improve ALA penetration. Laser pretreatment of the skin has been shown to increase the penetration of these photosensitizers. In an ex vivo porcine skin model, both continuous and fractional ablative Er:YAG lasers increased the penetration of topically applied ALA¹⁹ using a fluence of 4 J/cm^2 corresponding to a pore depth of approximately $12.5 \text{ }\mu\text{m}$ localized to the stratum corneum.

Another in vitro study showed that skin pretreatment with the fractional ablative Er:YAG laser increased the flux of ALA 27- to 124-fold in nude mouse skin and 3- to 260-fold in porcine skin, independent of the number of passes.²⁰ The skin received 1 to 6 passes (169 pores per pass) at a fluence of 2 or 3 J/cm^2 which corresponded to penetration depths of 8 and $12 \text{ }\mu\text{m}$, respectively. These investigators suggested that laser pretreatment of the skin could potentially reduce the required dose of topically applied ALA by 20%.

The fractional CO_2 laser has also been shown to enhance the delivery of photosensitizing agents used in PDT. Fractional CO_2 laser pretreatment of in vivo porcine skin significantly enhanced the penetration of topically applied MAL, along with the subsequent PDT response throughout the superficial and deep layers of the skin at fluences of 37 and 200 J/cm^2 .^{21,22}

Haak et al. investigated the importance of depth of ablation and incubation time for fractional CO₂ laser-assisted delivery of MAL in porcine skin,²³ and demonstrated that pretreatment with the laser significantly reduced incubation times required for a given accumulation of MAL from the skin surface to the deep dermis, compared to skin that was not treated with the laser.

Depth of ablation did not affect drug delivery, as the drug dispersed equally within the dermis for both shallow and deep MTZs, suggesting that once the epidermis is breached, MAL and other drugs may disperse readily within the dermis.

Daylight PDT

Daylight PDT is emerging as an effective treatment for AK, particularly for patients who require treatment of large areas of chronic actinic damage that can be exposed easily to daylight sun. Conventional PDT for AKs is associated with inconveniently lengthy clinic visits and discomfort during therapy. Three randomized controlled studies have shown that daylight-mediated PDT is an effective treatment of thin AKs. Benefits over traditional PDT include an almost pain-free experience, improved convenience, and the ability to easily treat large areas. Further investigation is needed to determine at which time of the year and in which weather conditions daylight-mediated PDT will be possible in different geographical locations,²⁴ though in Australia this has already become an effective and popular treatment option given the abundance of adequate daylight.²⁵

Postoperative considerations

After treatment, ice packs may be applied to the treated areas, though ice should not be placed in direct contact with the skin. Patients should avoid all sunlight exposure for at least 48 hours. Over the counter analgesics such as acetaminophen or ibuprofen may be used as needed (Fig. 70-4).



Figure 70-4. (A) A 38-year-old Caucasian female with Fitzpatrick skin type II with photodamage on her face prior to photodynamic therapy. (B) Patient 2 days after photodynamic therapy in the office. (C) Patient approximately 1 month after photodynamic therapy completed.

INDICATIONS FOR PDT

Medical indications for PDT

Actinic keratoses and nonmelanoma skin cancers

PDT is an attractive therapy for AKs as it allows treatment of large areas, has a high response rate, and results in excellent cosmesis. Because of the risk of transformation of AK to invasive squamous cell carcinoma (SCC), consensus guidelines recommend that AKs be treated to prevent progression to invasive disease. High-risk patients include those with a significant history of sun exposure, who reside in sunny climates, or have extensive outdoor work or recreational exposure. Additionally, solid-organ transplant recipients and other undergoing chronic immunosuppression are also at greater risk for developing AKs and for progression to SCC. Ninety-seven percent of SCCs are associated with a nearby AK.²⁶ One randomized controlled trial of nonhyperkeratotic AKs on the face and scalp using a 14- to 18-hour incubation period demonstrated an AK clearance rate of 72% to 85%.²⁷ In Europe, ALA and MAL research have focused on treating superficial cutaneous malignancies including SCC in situ and basal cell

carcinoma. PDT has also been studied as a primary preventive technique for skin cancer (Figs. 70-5 and 70-6).



Figure 70-5. (A) A 69-year-old Caucasian male with Fitzpatrick skin type II with several actinic keratoses on the forehead prior to receiving photodynamic therapy. (B) Same patient approximately 1 month after receiving photodynamic therapy for actinic keratoses.



Figure 70-6. (A) A 72-year-old Caucasian female with Fitzpatrick skin type II with several actinic keratoses prior to curettage and photodynamic therapy. (B) Same patient approximately 1 month after a single treatment of photodynamic therapy.

Acne vulgaris

Acne vulgaris is estimated to affect 70% to 96% of all individuals in their lifetime. Acne is primarily a disease of the pilosebaceous gland and is sometimes hormonally mediated and associated with *Propionibacterium acnes*. Challenges associated with medical treatment options are that conventional topical and systemic agents are associated with adverse effects, partial response, contraindications, and recurrence.

P. acnes produces endogenous protoporphyrins, including PpIX and coproporphyrin III, both of which have an absorption spectrum in the near ultraviolet range of light, with peak absorption seen at 415 nm. Thus exposure to blue light alone may be effective for acne, as photoactivation ultimately destroys *P. acnes*. Indeed, 63% of acne lesions responded to blue light alone, and 45% of comedonal acne also demonstrated a response. A variety of vascular lasers and IPL devices are also being used to treat acne vulgaris.²⁸

A recent review included 36 studies regarding the use of PDT.²⁹ These largely supported the role for PDT in acne management, though further research is needed to better define an ideal treatment protocol (Fig. 70-7).



Figure 70-7. (A) A 34-year-old Caucasian female with Fitzpatrick skin type II before receiving blue light treatment for facial acne. (B) Same patient after several treatments of blue light for acne vulgaris on face.

Hidradenitis Suppurativa

Hidradenitis suppurativa (HS) is a challenging disease, and there are reports of successful use of ALA–PDT using a blue light source (Fig. 70-8). One study evaluated patients with recalcitrant HS who were treated with short-contact ALA for three to four sessions with a blue light source over 1- to 2-week intervals. 75% of the HS lesions responded and remained clear during a 3-month follow-up.

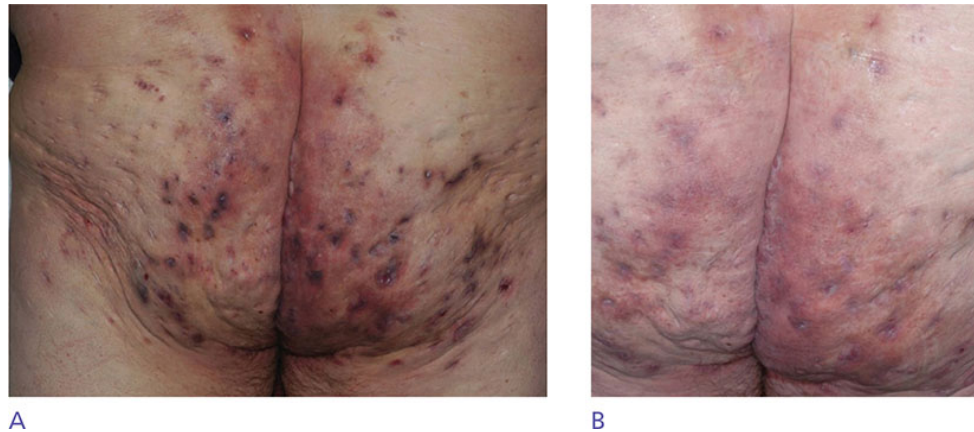


Figure 70-8. (A) A 43-year-old Caucasian female with Fitzpatrick skin type II with hidradenitis suppurativa before receiving photodynamic therapy on buttocks. (B) Same patient after four sessions of photodynamic therapy on buttocks.

Aesthetic indications for PDT

The aesthetic effects of PDT for photoaged skin are well documented, and improvement of lentigines, skin roughness, sallow complexion, and fine wrinkles has been demonstrated. A reduction in the histologic signs of photoaging, manifested as a decrease in solar elastosis and expression of p53, together with induction of neocollagenesis, has been shown as well.³⁰ One study evaluated IPL–PDT versus IPL alone for photoaging, and better results were achieved for the global score, fine lines, and coarse wrinkles on the PDT/IPL treated side than on the IPL-only side at the final visit.³¹ In another split-face trial of IPL/PDT versus IPL alone, similar efficacy of PDT treatment for the clinical signs of photoaging was seen.³² In another randomized trial, patients received three PDT treatments at 3-week intervals applied to half of the face 30 to 60 minutes prior to IPL treatment. The IPL/PDT group showed better results for global score for photoaging, improvement of fine lines and pigmentation. The final cosmetic evaluation by the investigator and subject satisfaction scores were both significantly superior on the IPL/PDT sides. However, there was also a higher incidence of side effects, including more intense erythema, scaling and dryness, edema, crusting, and vesiculation on the IPL/PDT side.

The molecular effects of ALA–PDT using a PDL for photoaged forearm skin have also been evaluated.³³ PDL/PDT was shown to induce collagen

production, as there were elevated levels of procollagen I and III mRNA, and procollagen I protein in the dermis. Other findings included an upregulated marker of keratinocyte proliferation (Ki67), and increased epidermal thickness. However, immunostaining for p53 did not show a decrease following PDL/PDT. Moreover, in comparison with PDL treatment alone, dermal remodeling was more pronounced with PDL/PDT (Fig. 70-9).



Figure 70-9. (A) A 36-year-old Caucasian female with Fitzpatrick skin type II before receiving photodynamic therapy and IPL on face for photodamage. (B) Same patient 1 month after receiving one treatment of PDT and IPL on face for photodamage.

COMPLICATIONS

Treated areas may become edematous and erythematous, and tissue response is directly correlated with the amount of photodamage. In some patients, a histamine reaction may occur with significant surrounding erythema. Patients may also develop superficial erosions accompanied by weeping and crusting. Infection during the postoperative period should be managed aggressively to mitigate the risk of scarring. In the event of moderate–severe pain or pruritus, patients should be seen and cultures may be performed. Prophylactic treatment may be initiated to prevent bacterial, viral, and yeast

infections. Patients should always be instructed to avoid sun exposure for 48 hours after ALA application due to cutaneous phototoxicity associated with increased sun exposure after treatment.

The most common complication of PDT is phototoxicity, presenting clinically as an exaggerated sunburn. Phototoxicity is most likely due to inadvertent outdoor exposure after PDT, and typically occurs within hours of excess photoactivation manifested as intense erythema, edema, and burning. Treatment includes rest, application of ice, and elevation (sleep on two pillows). Topical corticosteroid ointments, oral corticosteroids, and occlusive moisturizers may also offer some relief.

Another frequently seen complication is “stripping” caused by nonuniform ALA application or uneven laser activation. If stripping occurs, it can be easily corrected by a second treatment to clear the entire area. This should be distinguished from scarring caused by overly aggressive laser parameters or infection (Fig. 70-10).

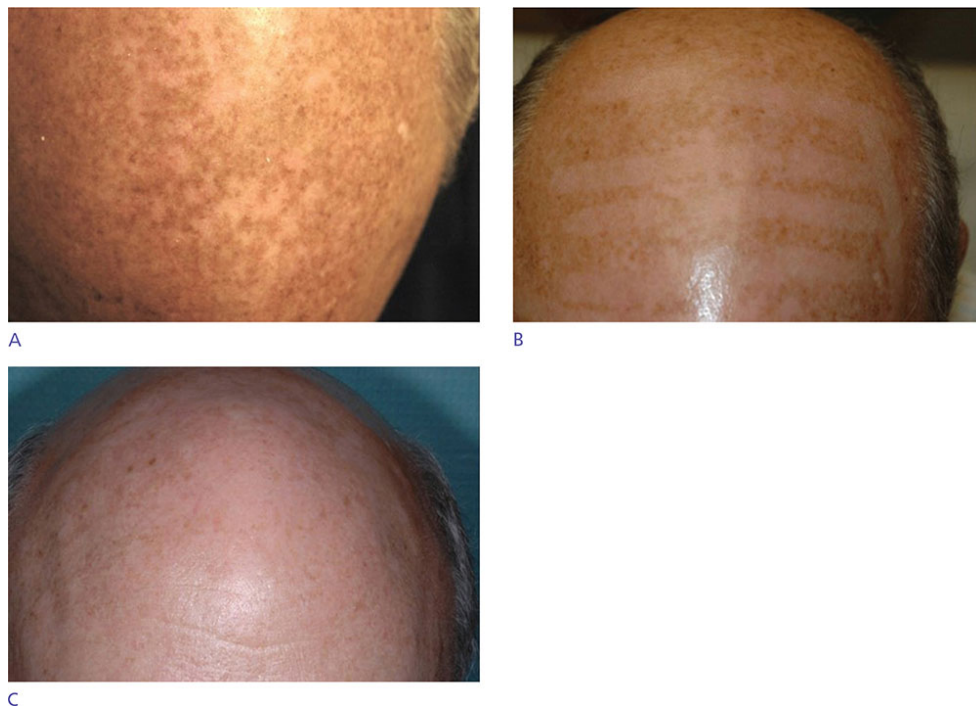


Figure 70-10. (A) A 75-year-old Caucasian male with Fitzpatrick skin type II with moderate to severe photodamage on the scalp prior to receiving photodynamic therapy and IPL laser. (B) Same patient approximately 1 month after PDT and IPL on scalp for photodamage; note the clinical appearance of stripping. (C) Same patient approximately 1 month after a second treatment of PDT and IPL on the scalp. Note the complete resolution of the stripping appearance.

Cutaneous viral and bacterial infections after PDT are uncommon, but may occur due to the impaired skin barrier postprocedure. Prophylactic antiviral agents are recommended in patients with a history of recurrent HSV infection within the treatment area. These medications are generally started 1 day prior to PDT treatment, and continued for 7 days. Patients with active herpetic lesions should not be treated due to the risk of diffuse spread and subsequent risk of scarring.

Patients are told to gently wash the face twice daily with a mild soap during the healing period. In addition, washing and an acetone scrub prior to PDT may decrease periprocedural infections. However, superficial bacterial infections such as impetigo or cellulitis may still be seen due to impaired skin barrier function, and may cause significant pain or pruritus. Patients should return for culture and appropriate topical and/or systemic antibiotic coverage if pain and itching increases, especially after day 2. Topical and oral antibiotics should be used until symptoms resolve. Rarely, patients may develop candidiasis associated with intense erythema and edema, which should be treated appropriately (Fig. 70-11).



Figure 70-11. (A) A 59-year-old Caucasian female with Fitzpatrick skin type II before receiving PDT and IPL treatment on the face for photodamage and actinic keratoses. (B) Same patient 1 week after PDT and IPL with erythema and edema, caused by candidiasis. (C) Same patient after applying topical nystatin ointment on the affected area twice a day for 10 days, along with taking oral antibiotics for 10 days.

Acute postoperative hypertension has also been reported after PDT for nonmelanoma skin cancer.³⁴ In this study, blood pressure was taken twice at

2-minute intervals before and after MAL–PDT. Prevalence of post-MAL–PDT APH was 22%, and 11% of patients developed hypertensive crisis. Therefore, blood pressure may be monitored in high-risk patients receiving MAL–PDT.

FUTURE DIRECTIONS

Future PDT light sources include LED³⁵ portable light sources, handheld devices, and an increased reliance on daylight PDT.

Third-generation photosensitizers (not yet approved) include lutetium texaphyrin and antibody-conjugated photosensitizers. These drugs have absorptions of 700 to 800 nm, allowing deeper penetration into tissues, and they can therefore be delivered selectively to the tumor tissue.^{36–38}

Other directions include a combination of PDT with other therapies and improved drug delivery technology. New studies with combination therapy using antiangiogenic agents (e.g., VEGF or COX-2 inhibitors) with PDT resulted in a significant reduction of PDT-induced expression of prostaglandin E2 and VEGF, as well as a marked improvement in tumoricidal response.^{39,40}

CONCLUSIONS

PDT is a noninvasive method of treating actinic keratoses, nonmelanoma skin cancers, acne, and cosmetic conditions. A variety of light sources may be used for activation, and daylight PDT is a promising area. PDT targets specific skin cells while leaving surrounding tissue unharmed. This treatment may be used in patients with nonmelanoma skin cancer, although additional studies are needed, and it lacks margin control. Pretreating the tumor to make it more susceptible to PDT may be another promising direction, though further research is needed.

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CHAPTER 71 Laser- and Light-Based Treatments in Skin of Color

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Henry Hin Lee Chan



SUMMARY

- In treating patients with skin of color, an understanding of the clinical implications of variations in skin structure and function as well as an appreciation of different cultural perceptions of beauty are pivotal in reaching a successful clinical outcome.

- Special consideration must be given to the appropriate use of laser parameters, including skin cooling and longer laser pulse width to protect the epidermis, longer laser/light source wavelength to reduce absorption by competing epidermal melanin, and higher fluences to achieve the desired clinical endpoint.
- PDL with dynamic cooling is effective in the treatment of PWS in patients with skin of color. The long-pulsed Alexandrite and 1,064-nm Nd:YAG laser can be used for the treatment of resistant PWS. Proliferative hemangiomas can be treated with low-fluence, long-pulsed PDL.

Beginner Pearls



- Light-colored complexion with an even skin tone is widely considered to be beautiful in Asian societies, and for this reason pigmentary disorders are a common indication for laser therapy.
- Preoperative measures to minimize PIH include sun avoidance for 2 weeks before and 4 weeks after laser treatment and avoidance of photosensitizing agents such as tetracyclines or oral contraceptives.

Expert Pearls



- LPDL with compression has been demonstrated to be an effective and safe modality to treat facial lentigines in Asian patients.
- The lack of photomechanical effects compared with QS lasers gives IPL an advantage in the treatment of lentigines and freckles in Asian patients.

Don't Forget!



- Factors that increase the risk of PIH include Fitzpatrick skin types IV to VI, recent sun exposure, and degree of inflammation at the dermal–epidermal junction.
- For the QS laser, it is best to use the smallest spot size to avoid injury to the surrounding normal skin and the lowest fluence to achieve immediate whitening.

Pitfalls and Cautions



- The laser removal of melanocytic nevi is controversial, as there is a small but theoretical risk of delaying diagnosis of melanoma, and the risks of inducing neoplastic changes with sublethal laser damage are unclear.
- Thus melanocytic lesions in patients with types IV to VI skin can be safely treated with laser therapy, provided that the lesion is not located in the acral area, the patient has no personal or family history of melanoma, and that the patient has been evaluated by a dermatologist.

Patient Education Points



- Sun protection is very important; the use of physical sunscreens with active ingredients such as titanium dioxide, zinc oxide, and iron oxide may be preferable to chemical sunscreens due to the lower risk of irritation.
- In general, there is a tradeoff between rapidity of action and low number of treatments and an increased risk of PIH and postoperative downtime. Thus treatment should be tailored to each patient's individual lifestyle and preferences.

Billing Pearls



- Almost all insurers in the United States exclude laser- and light-based treatments from coverage.
- Patients may benefit from committing to a series of treatments, as this may allow significant cost savings.

CHAPTER 71 Laser- and Light-Based Treatments in Skin of Color

INTRODUCTION

The term “skin of color” refers to the broad spectrum of skin complexions characterized by Fitzpatrick skin types IV to VI, melanocompetent skin types that typically tan easily and less commonly burn. This includes, but is not limited to, persons of Asian, Hispanic, African, and Native American ethnicity. In treating patients with skin of color, an understanding of the clinical implications of variations in skin structure and function as well as an appreciation of different cultural perceptions of beauty are pivotal in reaching a successful clinical outcome.

Variations in skin anatomy and physiology account for differences in responses to surgical intervention, laser treatments, and the clinical presentation and epidemiology of skin disorders between ethnic and Caucasian skin. Ethnic skin has a higher incidence of congenital and acquired pigmentary conditions including Nevus of Ota, Hori’s macules, lentigines, melasma, and seborrheic keratoses. Structurally, ethnic skin is characterized by an increased number of larger, individually dispersed melanosomes and increased tyrosinase activity which generates higher melanin content. This confers greater photoprotection and explains why pigmentary changes such as ephelides, seborrheic keratoses, and solar lentigines are the early manifestations of photoaging in ethnic skin, and the onset of wrinkling is

delayed 10 to 20 years compared with age-matched Caucasians.¹ In addition, ethnic skin has larger, more numerous fibroblasts with increased activity, therefore resulting in a higher prevalence of keloid and hypertrophic scarring.

Due to the higher epidermal melanin content in ethnic skin, skin treatment with lasers and light sources is challenging and may be associated with an increased risk of unwanted side effects. Melanin has a broad-absorption spectrum and acts as a competing chromophore which absorbs laser energy intended for other targets such as hemoglobin in blood vessels and pigment in hair follicles. Special consideration must be given to the appropriate use of laser parameters, including skin cooling and longer laser pulse width to protect the epidermis, longer laser/light source wavelength to reduce absorption by competing epidermal melanin, and higher fluences to achieve the desired clinical endpoint. This is imperative to improve clinical outcomes and—most importantly—to minimize the risk of side effects, particularly postinflammatory hyperpigmentation (PIH).

LASER AND LIGHT TREATMENTS FOR PIGMENTED LESIONS IN SKIN OF COLOR

Patients with skin of color have a higher incidence of both congenital and acquired pigmentary disorders such as nevus of Ota and Hori's macules. The early signs of photoaging in ethnic skin also manifest as pigmentary changes including solar lentigines, ephelides, melasma, and seborrheic keratoses. Despite the higher occurrence of pigmentary disorders, light-colored complexion with an even skin tone is widely considered to be beautiful in Asian societies, and for this reason pigmentary disorders are a common indication for laser therapy.

Prior to laser treatment, the patient's chief complaint, main objectives of treatment, and expectations should be carefully discussed, and informed consent obtained. By far the most common and important complication associated with the use of pigment-targeting lasers is PIH. Factors that increase the risk of PIH include Fitzpatrick skin types IV to VI, recent sun exposure, and degree of inflammation at the dermal–epidermal junction.

In the preoperative evaluation, detailed medical history including the history of oral retinoid use in the past 6 months, active infection, or recent

sun exposure of treatment area, history of keloid scar formation, photosensitivity, and personal or family history of melanoma should be excluded prior to laser treatment. Preoperative measures to minimize PIH include sun avoidance for 2 weeks before and 4 weeks after laser treatment and avoidance of photosensitizing agents such as tetracyclines or oral contraceptives. The use of physical sunscreens with active ingredients such as titanium dioxide, zinc oxide, and iron oxide may be preferable to chemical sunscreens due to the lower risk of irritation.

Treatment of specific lesions

Solar lentigines and freckles

The earliest and most common manifestation of photoaging in ethnic skin is the occurrence of solar lentigines and freckles.

Various laser modalities are available for the treatment of solar lentigines and freckles, including Q-switched (QS) lasers such as QS 532-nm neodymium:yttrium aluminum garnet (Nd:YAG) lasers, QS alexandrite laser (755 nm), QS ruby laser (694 nm), intense pulsed light (IPL) sources, and long-pulsed (LP) 532-nm Nd:YAG laser.

QS lasers are effective in the treatment of lentigines but are associated with a higher risk of PIH compared with IPL or LP laser. A study conducted by Chan et al. in 2000 compared the efficacy and complication rate of QS Nd:YAG 532 nm with LP Nd:YAG 532 nm in the treatment of facial lentigines in Asian patients and showed that while both types of lasers had similar efficacy, the QS laser induced greater risk of PIH.² This is due to the fact that QS lasers destroy melanin through both photomechanical and photothermal effects when short bursts (nanoseconds) of wavelength-specific energy are delivered to the skin. The undesirable photomechanical effects inflict damage to the adjacent oxyhemoglobin and cause inflammation to the superficial blood vessels and change in melanocyte activity, thus resulting in PIH. A similar study by Wang et al. in 2006 comparing QS alexandrite laser with IPL for the treatment of freckles and lentigines in Chinese patients demonstrated similar findings of a higher rate of PIH with the use of QS laser.³ Picosecond lasers have also been used for the treatment of lentigines. Although proposed to have a lower side-effect profile due to a much shorter

pulse duration, the photomechanical effect associated with such technology still led to PIH in about 5% to 10% (Fig. 71-1).⁴



Figure 71-1. (A) Lentigines. (B) Postinflammatory hyperpigmentation after one treatment of picosecond laser.

Long-pulsed dye laser (LPDL) 595 nm targets both hemoglobin and melanin. To minimize the unwanted effects on hemoglobin, which augment the risk of bruising and PIH, Kono et al. demonstrated that the use of diascopy during laser treatment with compression of the skin surface by the flat glass window on the handpiece leads to emptying of the blood vessels, reducing the subsequent bruising and PIH.⁵ LPDL with compression has been demonstrated to be an effective and safe modality to treat facial lentigines in Asian patients. The longer pulse duration associated with LPDL is better suited to target the basal cell layer with minimal photomechanical effects compared with the QS laser. However, due to the theoretical risk of dermal injury and scar formation caused by thermal diffusion injury from the epidermis to the dermis, the pulse duration should be either equal to or shorter than the thermal relaxation time of the epidermal basal layer, that is 1.6 to 2.8 ms for a 20- μ m thick basal layer.

IPL sources destroy pigment through photothermal effects and emit broadband of visible light (400–1,200 nm) from a noncoherent filtered

flashlamp. The lack of photomechanical effects compared with QS lasers gives IPL an advantage in the treatment of lentigines and freckles in Asian patients. However, with a large spot size, contrast between lesional and nonlesional skin needs to be taken into consideration. In skin of color, normal skin tends to have high melanin content, and therefore it is not uncommon for either a low fluence to be used—leading to poor therapeutic outcome—or an exaggerated response may occur affecting the normal skin leading to “footprint” injury.

Given the various laser modalities available, the ultimate choice of laser treatment depends on the patient’s expectations and willingness to accept possible complications such as PIH and prolonged downtime. An aggressive treatment approach is to use QS nano- or picosecond laser with one to two treatment sessions. This approach has the advantage being more cost effective, though patients should expect downtime for 1 week with a risk of PIH in the 5% to 10% range. A more conservative approach is to use the LPDL in three to four treatment sessions with very low risk of PIH and shorter duration of downtime. Prior to treatment, it is important to assess the contrast between lesional and nonlesional skin. If there is low contrast, avoid large spot size devices.

For the QS laser, it is best to use the smallest spot size to avoid injury to the surrounding normal skin and the lowest fluence to achieve immediate whitening (2-mm spot size, QS Nd:YAG 532 nm, 0.6 J/cm^2 fluence). Freckles show a good degree of improvement, with a PIH rate of not more than 5%. However, lentigines have a higher risk of PIH, at around 10%. For the LPDL, an ashen grey appearance is the desired clinical endpoint (LP 532-nm KTP/Nd:YAG, 2-mm spot size, 2-ms pulse duration, 6.5 to 8.0 J/cm^2 fluence without cooling or 12 to 14 J/cm^2 with cooling.)

Café-au-lait macules

Café-au-lait macules (CALM) are light-to-tan-brown hyperpigmented patches histologically characterized by the presence of giant melanosomes and increased melanin content. Various laser treatments for removal of CALM have yielded inconsistent results.

Of all laser modalities, QS lasers yield the most variable results, with high recurrence rates; paradoxical darkening has been reported. One possible explanation is that QS lasers fail to remove the follicular melanocytic component of the CALM. A retrospective study of treatment of CALM in

Chinese patients with QS 755-nm alexandrite laser showed that after an average of 3.2 treatments, good-to-excellent responses occurred in 54.1%, poor response occurred in 16.7% and recurrence in 10.4% of all patients.⁶ A similar study using QS 694-nm ruby laser and QS 532-nm Nd:YAG laser demonstrated similarly variable results.⁷

The current recommended approach is to use LP pigment lasers, such as normal-mode ruby laser (NMRL) or LP alexandrite laser without cooling to target not only the epidermal melanocytes but also the follicular melanocytes. NMRL was shown to have a lower risk of recurrence (42.4%) compared to QS ruby laser (81.8%) 3 months after a single treatment in a study of 33 patients with CALM.

Recently, the use of new laser devices operating at pulse durations in the sub-nanosecond range, the picosecond alexandrite laser, has been explored. Some cases that were previously resistant to treatment appear to be responsive (1.26–3.49 J/cm² fluence, 2.7–4.5-mm spot size, 2.5 Hz) although further study is needed (Fig. 71-2).

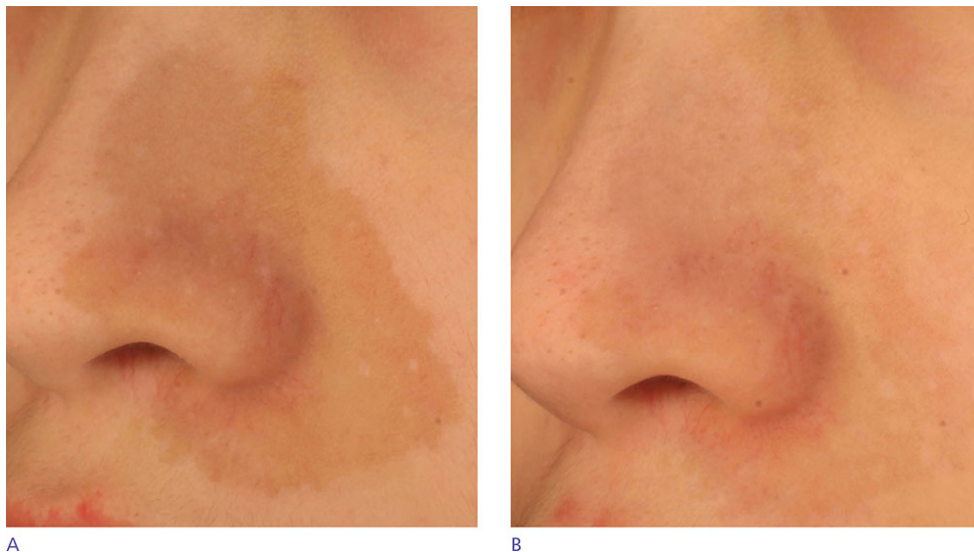


Figure 71-2. (A) Café au lait. (B) One month after three treatments of picosecond alexandrite laser (1.26–3.49 J/cm², 2.7–4.5 mm, 2.5 Hz); 4 weeks apart.

One approach to the laser treatment of CALM is to divide the lesions into four parts and test each area with four different lasers: LP Alex, QS ruby, PS Alex, and PS 532. Assessing the treatment response at each of the four areas will help guide the choice of laser modality. If the lesion persists after four

treatment sessions, discussion with the patient is warranted before commencing further treatment.

Becker's nevus

Becker's nevus is a pigmented hamartoma and appears as a unilateral hyperpigmented plaque with increased hair growth, usually located on the shoulder of male patients. The hyperpigmentation in Becker's nevus is due to the increased melanin content in melanocytes, and can be treated with QS ruby and frequency-doubled Nd:YAG lasers. A study comparing the use of erbium:YAG laser to QS 1,064-nm Nd:YAG laser in 22 patients after a follow-up of 2 years demonstrated that the erbium:YAG laser is significantly superior even after one treatment.⁸ LP pigment laser has also been employed to remove hair and pigmentation in Becker's nevus, though textural change is a possible complication.

LP alexandrite 755-nm laser (20–35 J/cm², 10-mm spot size, pulse duration 3 ms) is used to target the pigment and surrounding hair follicle. Normally, four to eight treatment sessions are performed with a 50% success rate. However, there are possible adverse effects including scarring and hypopigmentation. Recently, nonablative fractional resurfacing has also been used, with significant success (Fig. 71-3).^{9,10} The use of picosecond lasers for removal of Becker's nevus has also been explored, though further studies are needed (picosecond alexandrite, 2.08–3.49 J/cm², 2.5 Hz, 2.7–3 mm).



Figure 71-3. (A) Becker's nevus. (B) One month after five treatments of long-pulsed alexandrite laser (20–30 J/cm², 10 mm, 1.5 Hz), nonablative fractional laser (1,927 nm, 10–20 mJ, level 11, 82–164 MTZ/cm²); 4 weeks apart.

Nevus of Ota

Nevus of Ota occurs predominantly in patients with skin of color and in particular, in Asians and Blacks. It is a dermal melanocytic hamartoma and appears as a confluence of dusky blue and brown oval-shaped macules. The lesions are distributed in the skin and mucous membranes innervated by the first and second branches of the trigeminal nerve. Due to the anatomical location of the lesions, marked disfigurement and social stigmatization can occur. Fortunately, laser treatment with QS ruby 694-nm, QS alexandrite 755-nm, and QS Nd:YAG 1,064-nm lasers have all demonstrated excellent clinical results.

Effective treatment with QS ruby can be achieved with the smallest number of treatment sessions, though the risk of hypopigmentation is greater. Other potential complications include erythema after laser procedure, transient PIH, textural changes in the skin, and repigmentation which can occur in 0.6% to 1.2% of patients.¹¹

The QS alexandrite is better tolerated by patients in terms of postoperative discomfort compared with the QS Nd:YAG 1,064-nm lasers. In terms of clinical efficacy, QS Nd:YAG 1,064 nm appears to be superior to QS alexandrite after three or more laser treatment sessions.^{12,13} To further reduce the risk of purpura and dyspigmentation caused by inadvertent injury to neighboring blood vessels, a study showed that the use of compression during laser treatment with QS alexandrite laser caused diascopy and emptying of the cutaneous blood vessels, thereby reducing the risk of laser injury.¹⁴ Importantly, treatment efficacy was not compromised by compression.

Fractional resurfacing was also found to be effective in the removal of nevus of Ota in a patient that failed to respond after QS 1,064-nm Nd:YAG laser.¹⁵ However, this was an isolated case report, and the index patient had only received three QS Nd:YAG treatments.

Recently, the use of picosecond lasers for treatment of nevus of Ota has shown promising results with reduction in treatment sessions required without any increase in complication rate (Fig. 71-4).¹⁶

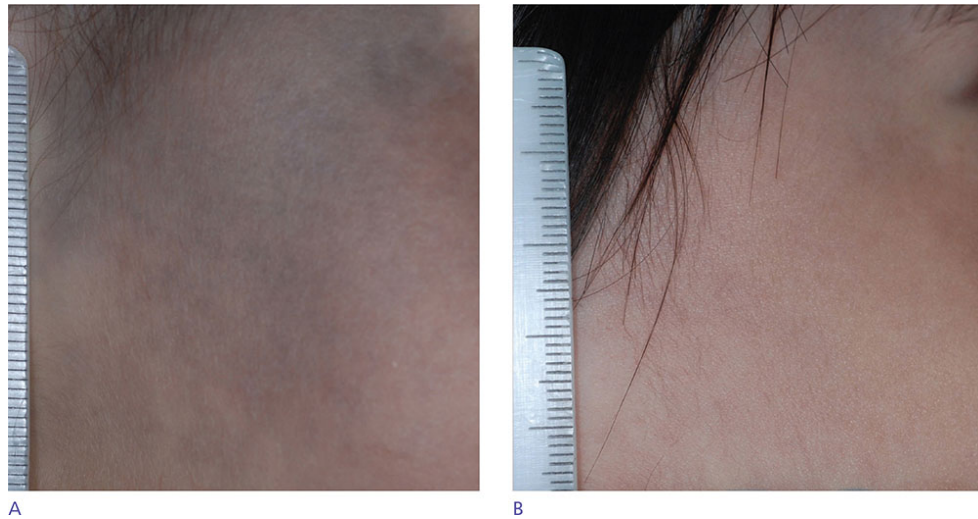


Figure 71-4. (A) Nevus of Ota. (B) Two months after five treatments of picosecond alexandrite laser (2.08–3.03 J/cm², 3–3.5 mm, 3.5 Hz); 4 to 8 weeks apart.

As patients often present in the pediatric age group, optimal timing of treatment needs careful consideration. Kono et al. examined the use of QS ruby laser in the treatment of nevus of Ota in different age groups and showed that the mean number of treatment sessions to achieve significant to complete clearing was 3.5 for the younger age group compared with 5.9 for the older age group ($p = 0.0001$).¹⁷ In addition, the complication rate for the younger age group was 4.8% as compared to 22.4% for the older age group. Early treatment is therefore advisable and has the added benefit of minimizing the psychosocial impact of the lesion.

Melanocytic nevi

The laser removal of melanocytic nevi is controversial, as there is a small but theoretical risk of delaying diagnosis of melanoma, and the risks of inducing neoplastic changes with sublethal laser damage are unclear.

However, important epidemiological variation exists in the incidence of melanoma in ethnic skin. The incidence of melanoma is significantly lower in ethnic skin compared with Caucasian skin, with the incidence in males at 32.3 per 100,000 person-years in the United States and 55.8 per 100,000 in Australia versus 0.2 per 100,000 in Japan.^{18–20} The site of occurrence of the melanoma also differs, and in Asians melanoma is typically located in non-sun-exposed areas including acral, subungual, and mucosal surfaces. Studies have shown that risks of malignant transformation of large congenital

melanocytic nevi and neurocutaneous melanosis in Asians are very low.²¹ Hale et al. performed a study on 205 patients with large congenital melanocytic nevi and found that 2.3% of patients developed melanoma.²² Larger size of the congenital melanocytic nevus and the presence of satellite lesions were significant risk factors for melanoma development.

The clinical implications are that melanocytic lesions in patients with type IV to VI skin can be safely treated with laser therapy, provided that the lesion is not located in the acral area, the patient has no personal or family history of melanoma, and that the patient has been evaluated by a dermatologist. For large congenital melanocytic nevi, clinicians should warn patients about the potential risk of malignancy.

One approach to the removal of melanocytic nevi is to use either an ablative laser (CO₂/erbium:YAG) or longer pulse pigmented laser (long-pulse 532 nm or ruby) to remove the epidermis and part of the dermis, followed by multiple passes of longer-wavelength QS laser (ruby/alexandrite/Nd:YAG).²³ Alternatively, fractional resurfacing can be employed with picosecond lasers in alternate sessions (Fig. 71-5).²⁴⁻²⁶



Figure 71-5. (A) Congenital melanocytic nevi. (B) Two months after eight treatments. (C) One year after total 19 treatments of long-pulsed alexandrite laser (15–40 J/cm², 10 mm, 1.5 Hz), Q-switched Ruby laser (3–5 J/cm², 5 mm, 2 Hz), nonablative fractional laser (1,550 nm, 65–70 mJ, level 11, 46–52 MTZ/cm²; 1,927 nm, 20 mJ, level 11, 82 MTZ/cm²), and picosecond alexandrite laser (6.37 J/cm², 2 mm, 5 Hz); 5 to 8 weeks apart.

Future directions in the management of congenital melanocytic nevi (CMN) include: DOPA injection/MSH to stimulate melanocytes to produce melanin in the deeper portion of the nevi and in doing so enhance the effect of laser treatment; utilization of more precisely controlled cryotherapy

techniques; and genotypic analysis of subjects to identify those at greater risk of melanoma development.

Treatment of vascular lesions

Laser treatment of vascular lesions, including salmon patches, port-wine stains (PWS), hemangiomas, and vascular malformations is challenging in patients with skin of color. The highly melanized epidermis of ethnic skin acts as a competing chromophore target for hemoglobin, resulting in an increased risk of side effects. Higher fluences are generally necessary to achieve clinical improvement. In a study performed by Goh et al., transient PIH was seen in all 36 Chinese patients with PWS treated with PDL.²⁷ Sommer et al. also reported that adverse effects, including hyperpigmentation, hypopigmentation, and atrophic scarring affected 8 out of 13 dark-skinned patients after PDL treatment.²⁸ Conversely, much lower complication rates were reported in a European series.²⁹ Newer laser technologies have revolutionized laser treatment of vascular lesions in dark-skinned patients. The use of epidermal cooling techniques, PDL with extended pulse durations, and fractional resurfacing have all led to improved clinical outcomes with minimal complication rates.

Device selection and laser parameters

Various laser devices are available for the treatment of vascular lesions, including the 532-nm Nd:YAG laser; 585/595-nm PDL; LP 755-nm alexandrite laser; LP 1,064-nm Nd:YAG laser; IPL; and fractional resurfacing. In choosing the most appropriate device and laser parameters best suited to the individual lesion and patient, several parameters need to be considered: wavelength, fluence, pulse duration, spot size, and the use of skin-cooling techniques.

Wavelength

Wavelength characteristics are an important parameter to consider when choosing the most appropriate laser device. A longer wavelength creates deeper tissue penetration. In dark-skinned patients, the use of short-wavelength laser devices such as 532-nm Nd:YAG are not recommended in

the treatment of PWS and hemangiomas. If the targeted vessels are located more superficially, such as those seen in facial telangiectasias, 532-nm Nd:YAG or LPDL can be effective. Based on published evidence, PDL with dynamic cooling is the gold standard for treatment of PWS in Asians. LP Alexandrite together with LP 595-nm PDL have been shown to be effective in combination for PWS cases that were resistant to PDL (Fig. 71-6).³⁰ The 1,064-nm Nd:YAG laser has been shown to be effective for the treatment of hypertrophic PWS on the lips to minimize the risk of dyspigmentation on the lips caused by PDL.³¹

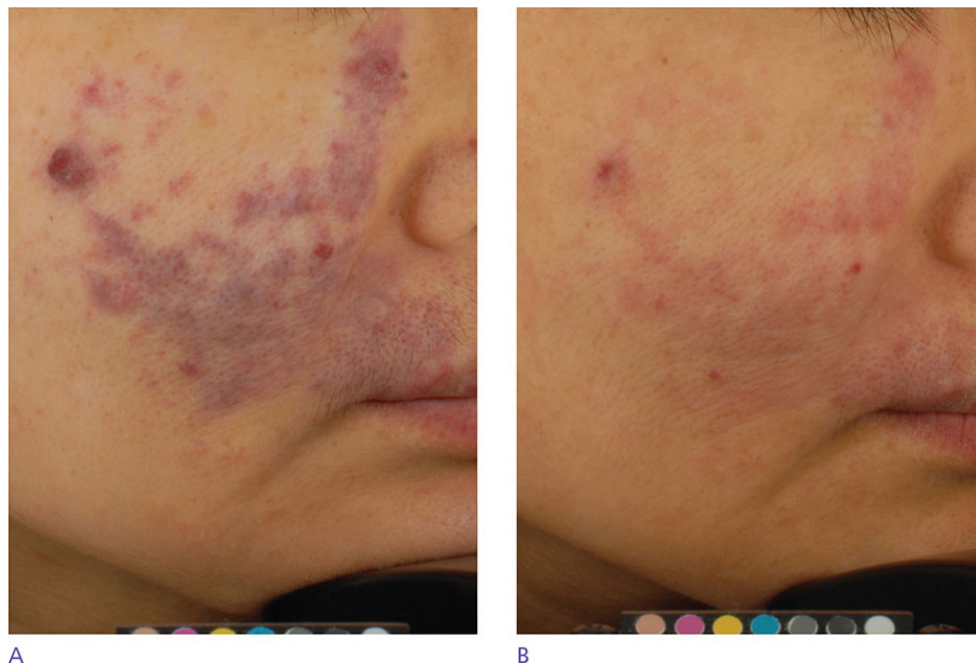


Figure 71-6. (A) Port wine stain. (B) One month after four treatments of long-pulsed alexandrite laser (35 J/cm², 10 mm, 1.5 ms), long-pulsed dye laser (6.75–13 J/cm², 7–10 mm, 1.5–6 ms), Q-switched Nd:YAG laser (1,064 nm, 3.1–3.5 J/cm², 2–8 mm, 5–10 Hz; 532 nm, 0.6 J/cm², 2 mm, 5 Hz); 4 to 8 weeks apart.

Pulse duration

In accordance with the principle of selective photothermolysis, pulse durations should be equal to or less than the vessel thermal relaxation time to maximize laser energy deposition and minimize thermal damage. Vascular lasers use longer pulse widths in order to damage larger blood vessels while sparing nonlesional small vessels and allowing greater epidermal sparing.³² However, in the treatment of PWS, purpura is the appropriate end point. The

choice of pulse duration depends on the type of lesion, vessel diameter, and degree of downtime the patient is willing to accept.

Spot size

Larger spot size causes a greater depth of thermal injury at the same fluence. In general, the larger the spot size the lesser the degree of scattering. When using the PDL, IPL, and 532-nm Nd:YAG lasers, larger spot sizes (>10 cm) can be used. In contrast, smaller spot sizes are recommended when using the alexandrite and 1,064-nm Nd:YAG laser to minimize bulk tissue heating and scar formation.

Epidermal cooling

Epidermal cooling has reduced the side effects and enhanced the clinical efficacy of vascular lasers. It is defined as the use of cooling substance to lower the skin surface temperature before, during, and after laser therapy. This allows for selective damage to the target structure and thermal injury to the epidermis from laser therapy can be reduced. Optimal cooling is necessary, and early cooling methods included water-cooled glass chamber devices, cryogen sprays, air cooling, and cold gel. Different devices have different cooling properties. Chan et al. showed that pigmentary and textural changes were seen in 33% of patients with PWS previously treated with LP KTP 532-nm laser with contact cooling alone.³³ Hence, more advanced cooling techniques are necessary and the concept of dynamic cooling with cryogen spray cooling (CSC) was developed. In CSC, a cryogen spurt is applied to the skin surface for tens of milliseconds to reduce the skin surface temperature from 30°C to 0° to –5°C to achieve optimal skin surface cooling. Chang and Nelson performed a retrospective study to examine the use of PDL with CSC (PDL-CSC) for the treatment of PWS among Asians.³⁴ The study showed that PDL-CSC enhanced the clinical efficacy and that a higher fluence (12 J/cm² instead of 8 J/cm²) could be achieved without an increase in complication rate. Chiu et al. also concurred that PDL-CSC was more effective and better tolerated than PDL alone for blanching of PWS in Chinese patients (Fig. 71-7).³⁵

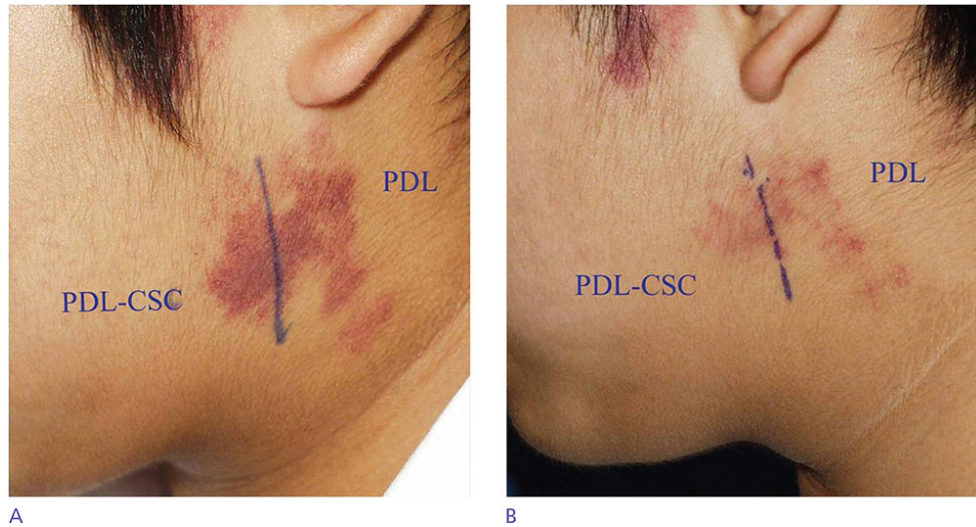


Figure 71-7. (A) Port wine stain. (B) Two months after three treatments of pulsed dye laser with cryogen spray cooling (PDL-CSC) or pulsed-dye laser.

Recurrence of PWS after laser treatment

Despite initial successful clinical response to laser treatment, problematic issues of redarkening still occur. Huikeshoven et al. conducted a 10-year prospective clinical study to examine whether redarkening occurs after PDL treatment of PWS.³⁶ A total of 51 patients were included in the study, and the results at long-term follow-up were compared with color measurements obtained before treatment and after an average of five laser treatments. On average, the lesion measured at follow-up was significantly darker compared with the measurement taken after the last of the initial five laser treatments ($p = 0.001$). However, it was still significantly lighter than measurements obtained before treatment ($p < 0.001$). Six percent of patients reported that the PWS had become lighter since their last treatment, 59% reported that it was unchanged, and 35% claimed that it had become darker.

Redarkening occurs because when laser destroys the blood vessels and subsequent hypoxia, inflammation and edema are also induced in the upper layers of PWS skin. Inflammatory cells migrate into these areas and secrete cytokines which are potent upregulators of proangiogenic factors. In addition, laser-induced wound healing as a response to PDL treatment often results in reformation of the PWS blood vessels.

Researchers have examined ways to modulate the wound-healing response after laser treatment to reduce risks of recurrence. One such method is to use topical angiogenesis inhibitors in combination with PDL treatment.³⁷ The use of combined PDL irradiation and a topically applied angiogenesis inhibitor was proposed to prevent revascularization. These compounds exert antiangiogenic and chemopreventive properties through a variety of mechanisms. Chang et al. performed a study on Asian patients to examine the combined use of PDL and topical imiquimod versus laser alone for treatment of PWS.³⁸ The results showed statistically significant differences in blanching responses over time favoring PWS receiving PDL and imiquimod as compared to either PDL or imiquimod alone ($p < 0.05$). The use of topical rapamycin has been also been shown to suppress the angiogenesis pathways induced by PDL.³⁹

Laser treatment of proliferative hemangiomas

The use of lasers to treat proliferative hemangiomas is more controversial. Early studies suggested a lack of efficacy while inducing risks of ulceration.⁴⁰ However, these studies did not utilize cooling techniques and used a small spot size. A study by Kono et al. compared the traditional PDL versus an LPDL in the treatment of childhood hemangiomas, and showed that LPDL demonstrated better clearance (65% vs. 54%; $p = 0.001$) with lower complication rates.⁴¹ Studies have showed that combination treatment with vascular lasers and fractional resurfacing demonstrate acceptable clinical outcomes (Fig. 71-8).⁴²

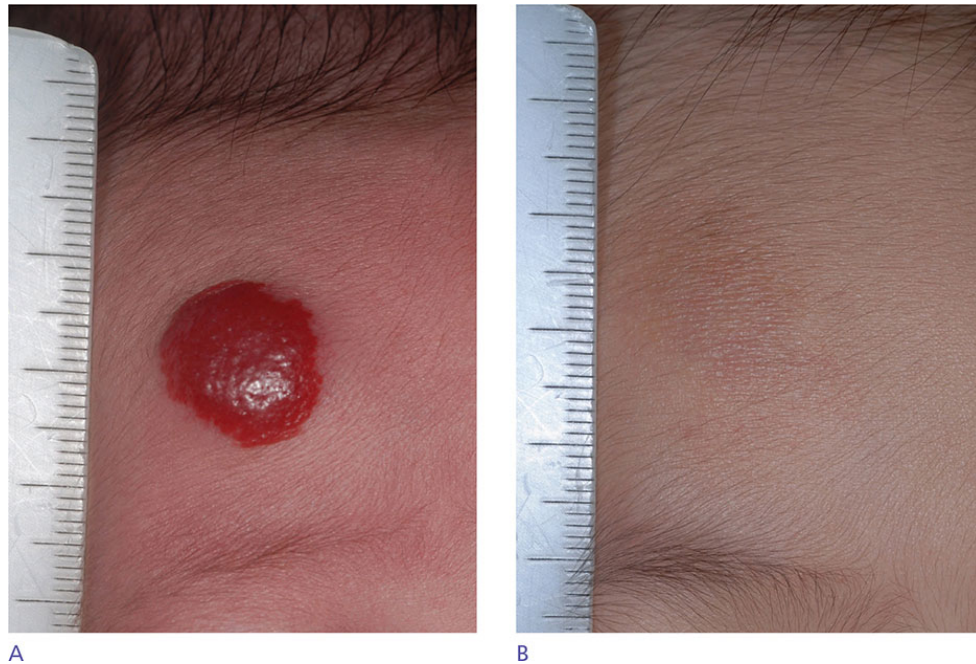


Figure 71-8. (A) Strawberry nevus. (B) One month after seven treatments of long-pulsed dye laser (9.8–13.3 J/cm², 3–7 mm, 1.5 ms), nonablative fractional laser (1,550 nm, 70 mJ, level 11, 48 MTZ/cm²); 4 to 24 weeks apart.

Future directions

Future directions of treatment of PWS include using noninvasive assessments of vascular structures in PWS (optical coherence tomography, OCT), SMART device (adding a colorimeter to improve cooling parameters), and methods to improve optical clearing. The use of photodynamic therapy (PDT) is also being explored. Gao et al. performed a direct side-by-side study in comparing the clinical efficacy of single treatment with PDL and PDT.⁴³ He concluded that PDT is at least as effective as and, in some cases, superior to PDL. A retrospective study of 581 patients compared PDL (585 nm, 0.45 ms) with PDT using hematoporphyrin monomethyl ether as photosensitizer and copper vapor laser showed that although there was no statistically significant difference in lesional clearing among pediatric patients, a higher rate of lesional blanching was observed in adults receiving PDT (94.2% vs. 88.4% with PDL).⁴⁴ However, despite such promising reports, cases of scarring after PWS treatment with PDT have been seen as well (Fig. 71-9).



Figure 71-9. Scar formation after single treatment of long-pulsed dye laser (11 J/cm², 7 mm, 1.5 ms).

In conclusion, the treatment of vascular lesions in patients with skin of color remains challenging and requires careful selection of the appropriate laser device and parameters. PDL with dynamic cooling techniques is effective in the treatment of PWS in patients with skin of color. The LP alexandrite and 1,064-nm Nd:YAG laser can be used for the treatment of resistant PWS. Proliferative hemangiomas can be treated with low fluence, LPDL. Ongoing research to combine topical antiangiogenesis agents together with laser treatment is currently underway to prevent PWS redarkening post laser surgery.

ABLATIVE, NONABLATIVE, AND FRACTIONAL SKIN RESURFACING

In the past, skin rejuvenation was performed using ablative lasers, such as carbon dioxide or Er:YAG lasers to remove the epidermis and part of the dermis. By removing the photodamage or scarred tissue, the subsequent healing process led to new collagen formation and resultant skin rejuvenation. However, the downtime and potential complications, including infection and even scarring, made such procedures less popular. Furthermore, skin of color patients generally have less wrinkling and are more prone to PIH.⁴⁵

Nonablative lasers involve the use of a cooling device to protect the epidermis and then deliver laser, light, or radiofrequency (RF) energy to the dermis; these devices have been the focus of attention in recent years. Together with lasers to improve other aspects of the skin components such as telangiectasia and lentigines, nonablative skin rejuvenation has gained significant popularity among skin of color patients. Typically, multiple devices are utilized including PDL, IPL, Nd:YAG, diode, Er:glass lasers, and RF.⁴⁶ Modest improvement in skin texture, scars, and rhytides is typically seen after a series of monthly treatments using these devices. There is little downtime, and adverse effects such as PIH and scarring are much less frequent when compared with ablative devices.

The development of fractional photothermolysis has revolutionized skin rejuvenation and resurfacing, attempting to achieve comparable clinical results to ablative lasers, but with a safety profile more similar to nonablative technologies.⁴⁷ In fractional photothermolysis, microcolumns of full-thickness thermal injury are induced to the reticular dermis while the stratum corneum is maintained intact. The skin has a unique epidermal repair system whereby necrotic debris and melanin are eliminated by keratinocyte migration and rapid expulsion. The extrusion and replacement of damaged tissue is analogous to resurfacing of the skin. The main objective of fractional resurfacing is to treat deeply and directly through both epidermal and dermal compartments while sparing fractional amounts of epidermis to maintain rapid reepithelialization. The microthermal wound zones heal to achieve true resurfacing effects and dermal remodeling effects. Barrier function remains intact due to the low water content of the stratum corneum.

This technology has proven to be effective in improving photoaging, dyschromia, rhytides, atrophic scarring, and poikiloderma.^{48,49} For skin of color, the main issue is PIH, and previous studies indicated that treatment density, rather than energy, is a stronger determining factor in the development of PIH.⁵⁰ By reducing the density and increasing the number of treatment sessions, clinical efficacy can be maintained with significant reduction of the risk of PIH (Fig. 71-10).⁵¹



Figure 71-10. (A) Acne scars. (B) One month after eight treatments of nonablative fractional laser (1,550 nm, 70 mJ, level 11, 48 MTZ/cm²); 4 to 12 weeks apart.

Low-energy, low-density nonablative fractional resurfacing using 1,440-nm diode laser or 1,947-nm thulium laser can be particularly useful for skin of color given the lesser degree of wrinkling but greater pigmentary issues seen in this population. A study suggested that low-energy and low-density 1,440-nm diode laser can be effective for the treatment of pigmentation and skin texture, especially among younger Chinese with limited adverse effects and down time.⁵²

Ablative fractional resurfacing (AFR) has been investigated for photorejuvenation and acne scarring in skin of color. Studies using a fractional CO₂ ablative device on Asians indicated improvement in skin texture, skin laxity, wrinkles, enlarged pores, and acne scars. PIH rate was

high and was reported to be 55.5% and 11.1% at 1 and 6 months post laser, respectively.⁵³

Other means to prevent PIH include reducing the density of each ablative fractional treatment; increasing the number of treatment sessions; and using topical or oral steroids have also been proposed, though the latter could be associated with a higher risk of infection.^{54–56} Other fractional ablative devices have been used with data indicating a slightly lower risk of PIH, including fractional Er:YAG laser and fractional RF.^{57,58} It is likely that a lower risk of complications correlates with a lower efficacy.

Fractionated picosecond lasers have also been used to treat acne scars, although it carries a lower risk of adverse events, the results appear to be less impressive as compared with nonablative fractional laser resurfacing.⁵⁹

BODY CONTOURING

Noninvasive body contouring has become increasingly popular. As opposed to traditional liposuction surgery, these devices are noninvasive and allow patients to avoid the risks of anesthesia and surgery, risks which are magnified when contemplating treatment for an essentially cosmetic indication. There are currently four major techniques of noninvasive body contouring; high-intensity focused ultrasound (HIFU,) RF, cryolipolysis, and laser. The underlying mechanism of action is postulated to be due to the efflux of triglycerides from fat cells which results in either reduced size or induced apoptosis of targeted adipocytes.⁶⁰

High-Intensity Focused Ultrasound

HIFU utilizes the same basic principles as diagnostic ultrasound, that is, the transducer generates acoustic waves that can travel through tissue. However, much higher power and tighter focus is used to quickly heat up and destroy fat while sparing superficial and surrounding structures. At high frequencies (2 MHz) the ultrasound energy is focused to target tissues of a specific depth, and restricts tissue injury to a focal point. An analogy is to focus light through a magnifying glass. Focused ultrasound can cause mechanical disruption of the adipocytes, and such technology has been used in combination with RF to

optimize the outcome. The heating leads to thermal coagulative necrosis of adipocytes. Necrotic adipocytes are then engulfed by macrophages and removed. Studies have not shown any resultant abnormalities in lipid profile, inflammatory markers, or liver and renal function after treatment with HIFU.^{61,62}

Asian patients typically have smaller physiques than their Caucasian counterparts. It is postulated that because of this reason, previous studies have shown that focused ultrasound is less effective for noninvasive body contouring in Southern Asians.⁶³ Shek et al. performed a study to evaluate the safety and efficacy of a HIFU device for sculpting of the abdomen in Asian patients.⁶⁴ All 12 patients received a single HIFU treatment with total fluence of 150 to 165 J/cm² and this reduced waist circumference by 2.1 cm at 12 weeks post-treatment. The range of fluence per pass was 30 to 55 J/cm². The results showed that 7 out of 12 subjects were satisfied with the outcome and 9 out of 12 would recommend this treatment to their friends and family. Statistically significant improvement was seen in the waist circumference measured at both the iliac crest ($p = 0.013, 0.002, 0.005$) and maximum waistline ($p = 0.003, 0.034, 0.023$) at 4, 8, 12 weeks post-treatment (Fig. 71-11). In addition, it was shown that the higher the total fluence delivered, the larger the decrease in waist circumference. The study concluded that HIFU was effective in reducing the waist circumference in Chinese patients. However, HIFU is associated with a drawback in that 11 out of 12 patients developed bruising. One patient developed folliculitis. The mean pain score on visual analog scale was also 5.7. Hence, another study examined the use of a low frequency focused ultrasound together with the use of an RF applicator to reduce the side effects of treatment.⁶⁵ The bipolar RF handpiece creates a lower resistance pathway to allow for selective heating of the fat prior to applying the focused ultrasound energy. This study, which was also performed in Asian patients, showed that while efficacy was comparable, more treatment sessions (three as compared to one) were required, but that there were fewer side effects. Only 6 in 20 patients reported wheal formation, and less than one-third reported moderate to severe pain (Fig. 71-12).

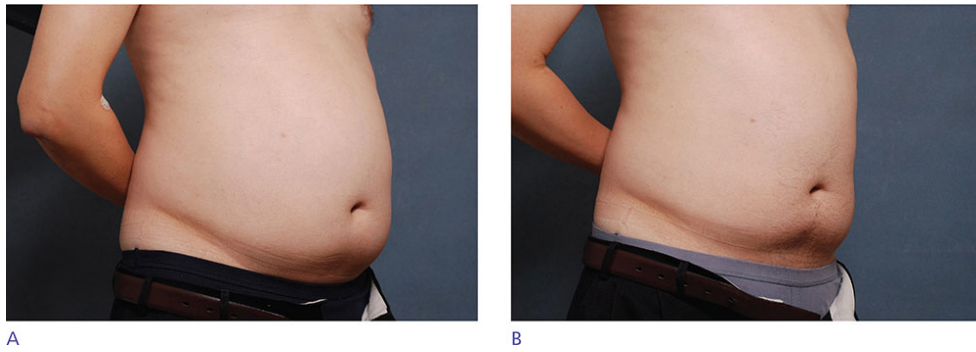


Figure 71-11. (A) Baseline abdomen. (B) Two months after single treatment of high-intensity focused ultrasound.

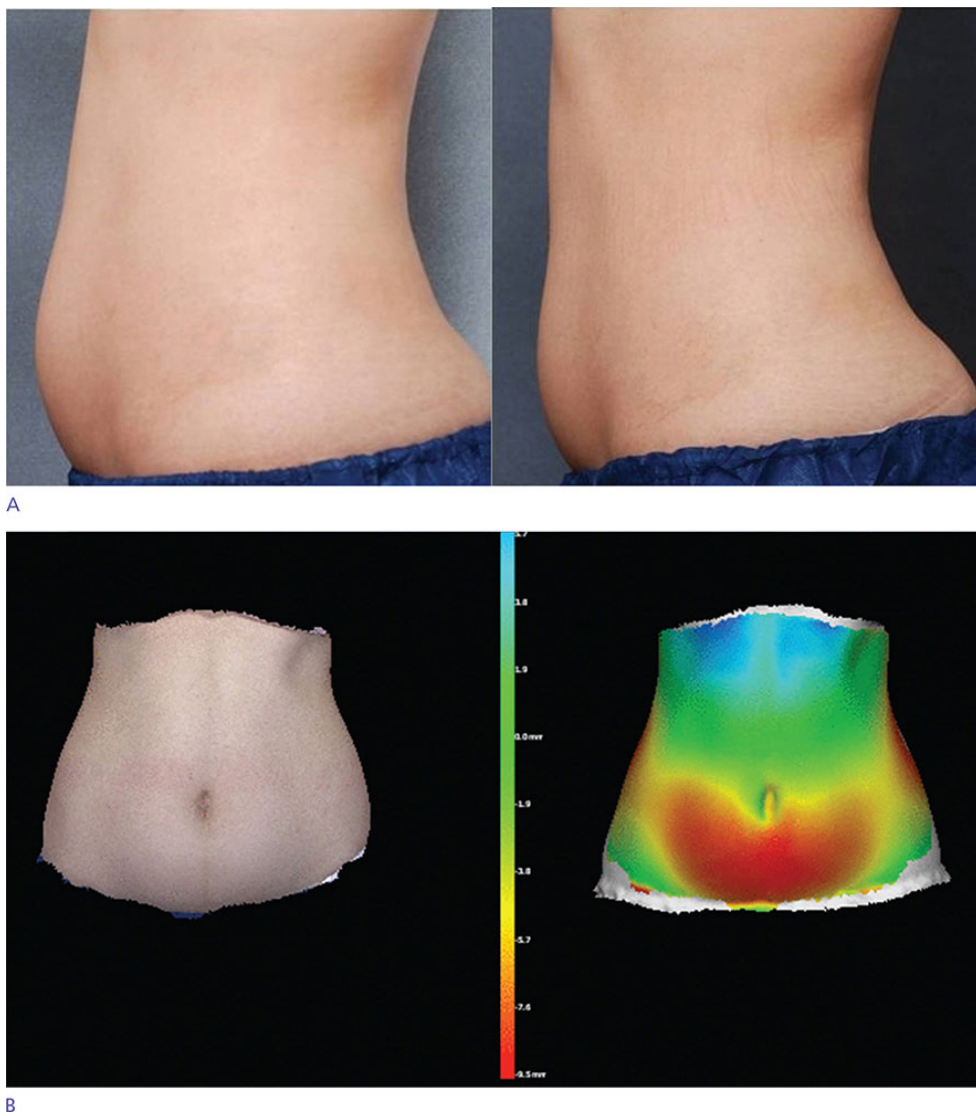


Figure 71-12. (A) Baseline abdomen (left) and three months after three combined treatments of high-intensity focused ultrasound (HIFU). (B) Note the well defined abdominal contour post-procedure.

Cryolipolysis

In cryolipolysis, the adipose cells are cooled to temperatures below normal, but above freezing to induce apoptosis without collateral damage to surrounding tissues. The cooling causes crystallization of lipids in the adipose cell and apoptosis is triggered by slow dissolution of cell contents. Fat reduction gradually occurs over the next several months, and about 20% of fat reduction can be achieved.

Apoptosis is triggered and the dead cells dissolve, resulting in body contouring.⁶⁶ Shek et al. examined the use of cryolipolysis for body contouring in Chinese patients and showed that patients who received a single treatment (one 1-hour treatment to the body trunk, cooling intensity factor preset to -73 mW/cm^2) had significant improvement ($p < 0.001$, Fig. 71-13).⁶⁷ In addition, patients who received two 1-hour treatments also showed significant improvement compared to baseline, though the extent of improvement was not as marked compared with the first treatment. The side-effect profile was favorable, with all pain, redness, and numbness being transient. Two out of 21 patients who received one treatment had bruising, whereas none of the patients who received two treatments had bruising.

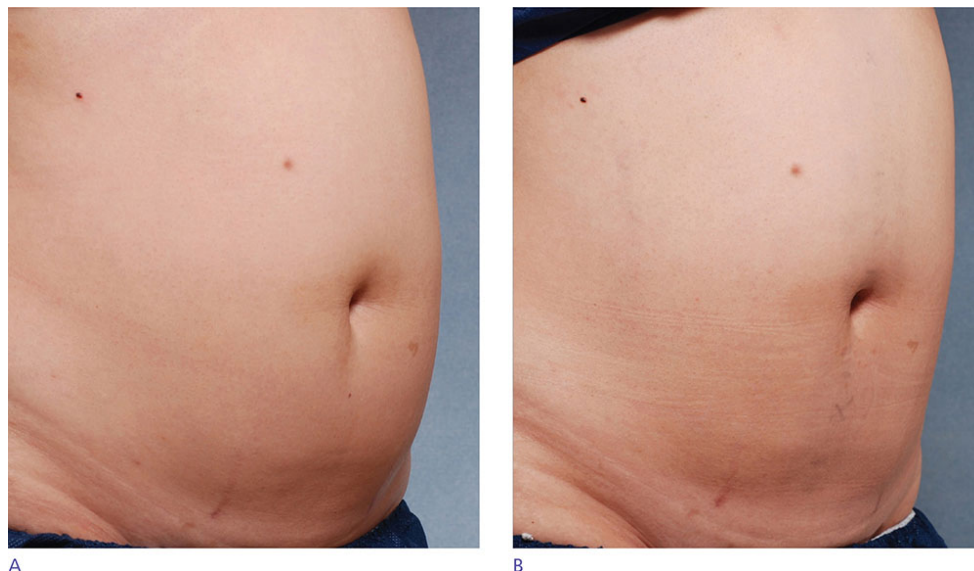


Figure 71-13. (A) Baseline abdomen. (B) Two months after single treatment of cryolipolysis.

Laser

635- to 915-nm low-level lasers have been used for body contouring. The latest laser system utilizes 1,060-nm high-energy diode laser with cooling to increase efficacy and tolerability. The use is applicable to all Fitzpatrick skin types, and has been FDA approved. The 1,060-nm diode laser disperses laser energy to adipose cells and induces injury at 42° to 47°C. The subsequent delivery of a laser pulse and cooling protect the upper layers of the skin. A single 25-minute treatment is effective for treating the abdominal area (fluence start at 1.1 W/cm² increasing based on the feedback of subject's tolerance, with a maximum fluence not exceeding 1.4 W/cm²). The maximum number of applicators is four. No complications have been noted to date and only mild pain and redness were noted after the procedure (Fig. 71-14).

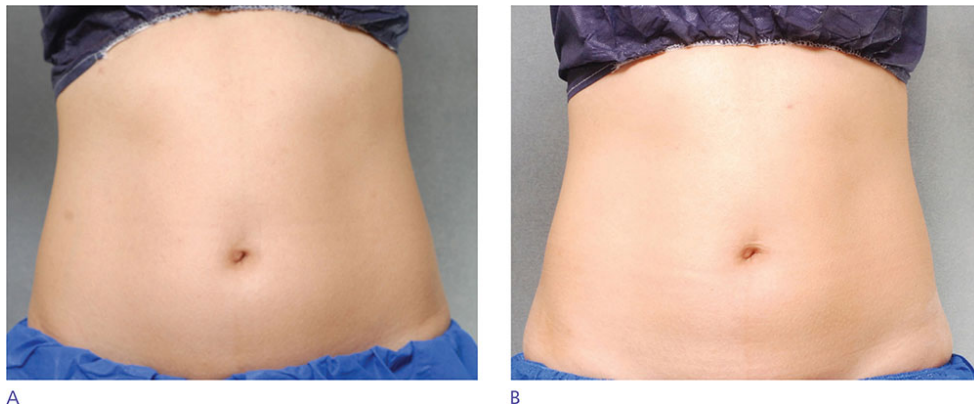


Figure 71-14. (A) Baseline abdomen. (B) Three months after two treatments of diode laser (1.1–1.4 J/cm²); 6 weeks apart.

CONCLUSIONS

Laser treatment of ethnic skin continues to be challenging given the higher melanin epidermal content and increased risk of complications, particularly PIH. However, successful treatment is achievable with careful patient selection and utilization of appropriate laser parameters.

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CHAPTER 72 Sclerotherapy and Management of Varicose Veins

Neil Sadick



SUMMARY

- Sclerotherapy is a highly effective technique for the treatment of varicose veins.
- Sclerosants may be divided based on whether they exert osmotic or detergent effects on the vessels.
- Both liquid and foam sclerotherapy may be used, depending on vessel caliber.

Beginner Tips



- Common sclerosants include sodium tetradecyl sulfate (STS), polidocanol, and hypertonic saline.
- Larger caliber vessels may benefit from foam sclerotherapy, which can be prepared immediately prior to use.

Expert Tips



- Vessels should be treated from deep to superficial.
- Treating with Nd:YAG laser after sclerotherapy may be helpful and lead to markedly increased levels of response.

Don't Forget!



- Maintaining or increasing activity in the postprocedure period is of vital importance.

- Superficial thrombophlebitis is common after surgery, and localized urticarial reactions may be seen as well.

Pitfalls and Cautions



- Microemboli are frequently seen after foam sclerotherapy, and vision changes, while rare, are possible.
- DVT is a significant risk post treatment, and patients should be warned of this risk.

Patient Education Points



- The risk of DVT and vision changes, while unusual, should be discussed at length with all patients.
- Compression stockings are very helpful in the postoperative period, and ace wraps should be avoided.

Billing Pearls



- In the United States, insurance generally does not cover sclerotherapy, even when performed for symptomatic patients. Motivated patients with symptomatic disease may wish to contact their insurer to assess coverage.

CHAPTER 72 Sclerotherapy and Management of Varicose Veins

INTRODUCTION

Varicose veins are a common problem, and represent a symptom of chronic venous disease that encompasses a wide spectrum of morphologic (venous dilation) and functional (venous reflux) abnormalities.^{1–3} Vein-related problems may be symptomatic, and range from minimal superficial venous dilation to chronic skin changes with ulceration.

Depending on associated signs and symptoms, chronic venous disease manifestations have been stratified in classes from C0 to C6 based on the Clinical-Etiology-Anatomy-Pathophysiology (CEAP) classification ([Table 72-1](#)). Using this classification, chronic venous insufficiency is generally restricted to disease of greater severity (i.e., classes C4–C6).⁴ Thus, varicose veins (CEAP category 2) in the absence of skin changes are not indicative of true chronic venous insufficiency. They are dilated, elongated, tortuous, subcutaneous veins 3 mm or greater in diameter that may involve the saphenous veins (great or small), saphenous tributaries, or nonsaphenous superficial leg veins ([Fig. 72-1](#)). Varicose veins are present in 10% to 30% of the general population, with increasing rates in older individuals.^{5,6} Although they are generally thought to be more common in women than men, depending upon the population evaluated, men may have a higher rate of disease.^{5–7}

Table 72-1. CEAP Classification¹

Clinical classification

- C0 No visible or palpable signs of venous disease
- C1 Telangiectasias, reticular veins, malleolar flares
- C2 Varicose veins
- C3 Edema without skin changes
- C4 Skin changes ascribed to venous disease (e.g., pigmentation, venous eczema, lipodermatosclerosis)
- C4a Pigmentation or eczema
- C4b Lipodermatosclerosis or atrophie blanche
- C5 Skin changes as defined above with healed ulceration
- C6 Skin changes as defined above with active ulceration
- S Symptomatic, including ache, pain, tightness, skin irritation, heaviness and muscle cramps, and other complaints attributable to venous dysfunction
- A Asymptomatic

Etiologic classification

- Ec Congenital
- Ep Primary
- Es Secondary (postthrombotic)
- En No venous cause identified

Anatomic classification

- As Superficial veins
- Ap Perforator veins
- Ad Deep veins
- An No venous location identified

Pathophysiologic classification

- Pr Reflux
- Po Obstruction
- Pr,o Reflux and obstruction
- Pn No venous pathophysiology identifiable

Data from Eklof B, Rutherford R, Bergan J, et al. Revision of the CEAP classification for chronic venous disorders: Consensus statement, *J Vasc Surg*. 2004 Dec;40(6):1248–1252.



Figure 72-1. Varicose vein (CEAP: C2).

Treatment of varicose veins depends on symptoms, extent of lower extremity disease, patient expectations, and likelihood of providing a durable benefit either with respect to appearance or improvement in symptoms. Typical strategies include excision, laser therapy, sclerotherapy, or combination approaches.

Sclerotherapy is a minimally invasive procedure wherein veins are injected with a sclerosing agent that causes endothelial damage by either detergent or osmotic action. After treatment, the target vein shrinks, and over

a period of weeks the treated vein is gradually resorbed. The procedure itself usually lasts no more than 10 minutes, and compared to true surgical vein removal the downtime is minimal. Currently, sclerotherapy is considered the “gold standard” and preferred strategy to treat small varicose leg veins.⁸ Sclerotherapy is also superior to laser ablation in its ability to close feeder veins or complex venous networks, thus reducing the rate of potential recurrence.

Two main types of sclerotherapy exist, liquid and foam, and both have been successfully used to treat varicose veins.^{9–11} Liquid sclerosant preparations are typically used to treat small varicose veins. Foam preparations are available to increase the surface area of the sclerosant and decrease the volume of sclerosant needed when applied to the treatment of larger varicosities, incompetent saphenous veins, and perforators. Multiple injections of dilute sclerosant are injected into the abnormal surface veins of the involved leg. Ultrasound-guided sclerotherapy (UGS), with the injection of the sclerosant at the level of refluxing perforator veins, has also been used to treat the associated clusters of varicose veins with good long-term results and without significant complications, but requires an experienced practitioner.

ETIOLOGY

Veins are responsible for ensuring blood return to the heart, and a series of valves close between heartbeats to prevent retrograde flow. A varicose vein occurs when a valve weakens, putting more pressure on other valves and causing blood to stagnate. The vein then becomes distended and endothelial walls stretch, allowing the vein to swell locally into a miniature balloon near the surface of the skin. There are several risk factors for varicose vein formation, including advancing age, family history of venous disease, ligamentous laxity such as hernia, platypodia, prolonged standing, increased body mass index, smoking, sedentary lifestyle, lower extremity trauma, prior venous thrombosis (superficial or deep), the presence of an arteriovenous shunt, some hereditary conditions, high estrogen states, and pregnancy.^{5,12–17}

Many studies have suggested a strong familial component to the development of varicose veins.¹⁸ In a case-control study of 67 patients and their parents, the risk for varicose veins was 90% when both parents were

affected, 25% for men and 62% for women when one parent was affected, and 20% if neither parent had varicose veins.¹⁹ A recent genetic study demonstrated that polymorphisms of matrix metalloproteinase 9 (MMP9) and specific tissue inhibitors of MMP (TIMP2) genes were associated with susceptibility for varicose vein formation, and individuals with specific genotypes may have a lower risk for varicose vein formation.²⁰

Since prevalence rates appear to be lower in non-Western populations, it has been widely thought that factors related to Western lifestyle, such as prolonged standing and sitting increase the likelihood of the development of varicose veins.²¹ A longitudinal study from 1999 to 2004 in 38,036 patients found that risk of surgery for varicose veins was associated with prolonged standing/walking and heavy lifting, with more than 60% of cases seen in those with high-risk occupations.²² Several other studies in individuals with occupations that require prolonged standing, such as midwives and hairdressers, have confirmed these results.^{23–25} Increased body mass appears to be a significant aggravating factor.²⁶

Pregnancy is also presumed to be a major contributory factor in the increased incidence of varicose veins in women, affecting about 40% of pregnant women. Moreover, multiparous women have a higher incidence of varicose veins compared with nulliparous women.^{27,28} Both the increased blood volume that increases venous pressure and hormones such as progesterone that relax the muscular walls of blood vessels aggravate the venous ability to ensure blood flow back to the heart. Moreover, the increasing weight of the growing uterus puts pressure on the pelvic veins and on the inferior vena, increasing blood pressure in the leg veins, thus influencing the development of varicose veins. Estrogen and progesterone receptors have been found in saphenous veins, and although their function is not yet known, it has been hypothesized that they may provoke venous dilation and valvular failure in pregnancy.²⁹

INDICATIONS

Varicose veins may occur in the presence or absence of either symptoms or an underlying functional venous disorder, such as reflux.³⁰ Candidates for sclerotherapy manifest persistent symptoms (such as pain, aching, and

swelling) and signs (such as telangiectasias, reticular veins, varicose veins, pigmentary changes, and ulceration) of venous disease after 6 months of medical therapy.

Sclerotherapy techniques to achieve perforator and saphenous closure are available for patients with documented reflux (i.e., retrograde flow >0.5 second duration) as a source of their symptoms. For patients with ulceration refractory to medical management, or those who manifest recurrent ulceration, UGS of perforators can lead to significant reduction of symptoms and signs. For small varicosities that are mostly a cosmetic concern, sclerotherapy can be performed following physical examination without additional diagnostic studies, as these patients are not as likely as symptomatic patients to have underlying venous reflux.^{30,31} Patients with complaints of recurrent bleeding and stigmata of recent venous hemorrhage may benefit from sclerotherapy of that vein site.^{32,33} Sclerotherapy is often successful even in the presence of venous insufficiency.³²

ANATOMICAL CONSIDERATIONS

Intimate knowledge of the venous system and interconnections between the veins is a prerequisite prior to performing sclerotherapy. The axial veins of the venous system of the lower extremity are divided into the superficial and deep systems. Veins that traverse the same system are termed communicating veins, whereas veins that connect the superficial to the deep system are called perforating veins. The superficial veins are contained in the subcutaneous tissue of the lower extremity within a superficial space that is bounded deeply by the muscular fascia and superficially by the dermis. The major axial superficial veins of the lower extremity include the great and small saphenous veins. Other lower extremity superficial veins with more variant anatomy include the anterior, posterior, and superficial accessories of the great saphenous vein (GSV), the superficial accessory of the small saphenous vein, intersaphenous veins, and the lateral venous system (Fig. 72-2).

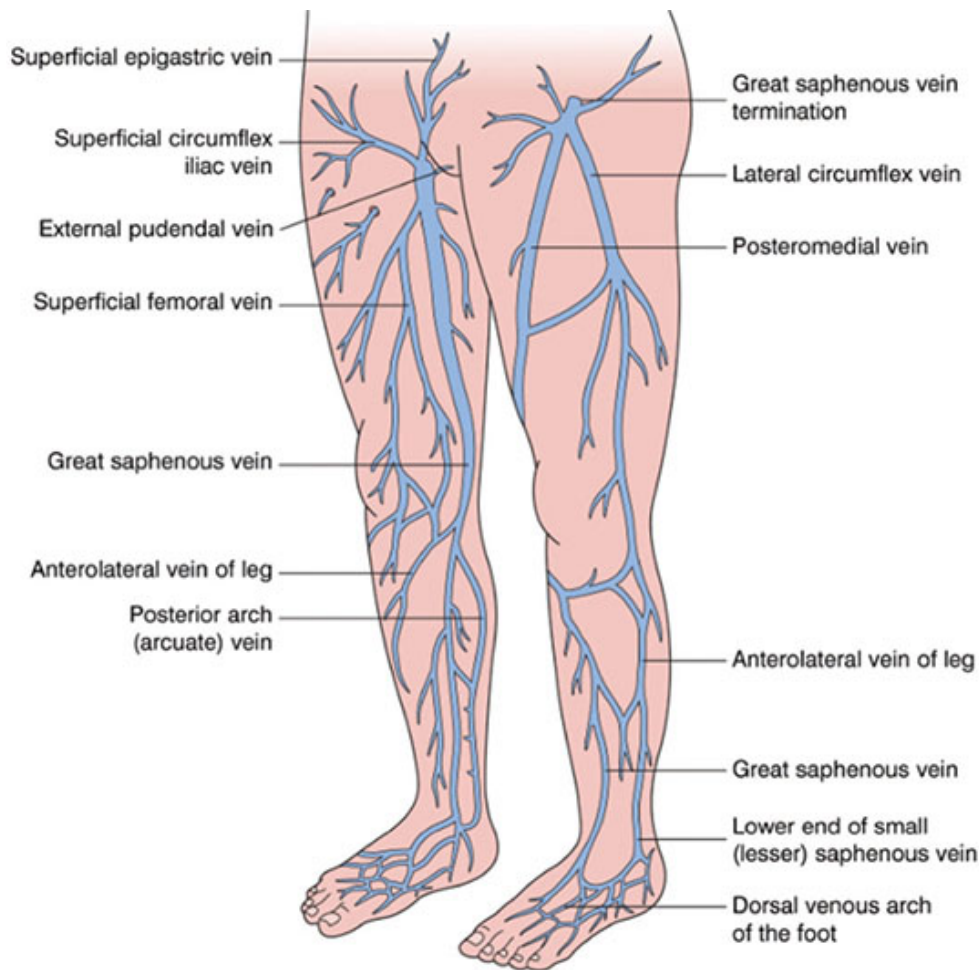


Figure 72-2. Superficial veins of the lower extremity. (Reproduced with permission from Bologna JL, Jorizzo JL, Rapini RP: *Dermatology*, 2e. Philadelphia: Elsevier, Inc.; 2008)

The deep veins of the lower extremity are contained within the deep muscle compartments bounded by the muscle fascia (Fig. 72-3). The deep veins of the lower extremity are classified as intramuscular (within a single muscle) or intermuscular (between muscle groups). The intermuscular veins are more important in the development of chronic venous disease. Sclerotherapy is effective in destroying a segment or length of vein that is usually axially oriented, though it cannot safely and predictably eradicate a circumferential finite point of reflux, such as a junction at which two veins converge, without the potential risk of concomitantly obliterating some length of vein distal and proximal to this point of reflux. As an example, injection of a sclerosant at the point of an incompetent saphenofemoral junction could produce destruction of the adjacent segments of the femoral vein and the

greater saphenous vein. Injection of a sclerosant seldom obliterates incompetent perforating veins, but merely the varicosity of the superficial venous system into which these perforating veins empty. It is advised that all sites of reflux from the deep venous system into the superficial varicosities should be surgically treated before sclerotherapy, as this would diminish the development of new varicosities by preventing retrograde flow, as well as associated elevated venous pressure, into adjacent competent veins. It also aids in minimizing retrograde flow into existing varicosities that are the targets of treatment.³⁴



Figure 72-3. Cross and longitudinal sections from ultrasound-guided foam sclerotherapy (UGFS) after treatment of great saphenous vein.

CONTRAINDICATIONS

Sclerotherapy should not be performed in patients who have signs of acute thrombosis or phlebitis, due to the increased risk of deep venous thrombosis. Pregnant patients should defer treatment until after delivery. Diabetes and peripheral arterial occlusive disease (ankle–brachial index <0.9) are relative contraindications, as they pose a risk for wound healing complications, but this depends upon the nature and extent of sclerotherapy being considered. A history of migraine headache and patent foramen ovale are also relative contraindications to sclerotherapy, due to the risk for microembolism.^{35–39} Those with a history of hypersensitivity and allergic reactions to any of the sclerosants should be pretested to mitigate the risk of anaphylaxis. Sclerotherapy should not be performed to individuals with active infections due to the risk of bacterial spread. Immunocompromised patients and cancer patients receiving chemotherapy should not be treated due to an increased risk of thromboembolic events. Women treated with tamoxifen are at a higher risk for thromboembolic complications during the first 2 years after exposure.⁴⁰

WORKUP

Inspection and palpation are important elements necessary to identify venous disease. Photography can be critical, as patients undergoing treatment for varicose veins often forget the original appearance of their legs, and frequently report that pre-existing lesions were caused by treatment. Inspection is performed in an organized manner, usually progressing from proximal to distal and from anterior to posterior. The perineum, groin, and abdominal wall must also be inspected. Normal veins typically are visibly distended at the foot and ankle and occasionally in the popliteal fossa, but dilated veins above the ankle usually are evidence of venous pathology. Inspection may reveal such findings such as stasis dermatitis, lipodermatosclerosis, ulceration, atrophie blanche, interdigital mycosis, acrocyanosis, eczematous lesions, flat angiomas, clusters of telangiectatic

veins, corona phlebectatica, hemosiderin deposition, prominent varicose veins, scars from a prior surgical operation, or evidence of previous sclerotherapy. Skin discoloration or ulceration along the medial aspect of the lower leg often is a sign of chronic venous stasis. Skin changes or ulcerations that are localized only to the lateral aspect of the ankle are more likely to be related to prior trauma or to arterial insufficiency, though small saphenous venous insufficiency may present in this manner as well. Palpation should begin along the anteromedial surface of the lower limb proceeding to the lateral and then finally to the posterior surface of both lower limbs. The location and course of all varicosities should be carefully noted. The GSV may be palpated in thin patients without varicose veins, but it is particularly well appreciated in patients with truncal reflux at the saphenofemoral junction. If reflux is present, a forced cough or Valsalva maneuver may produce expansion at this level. The small saphenous vein may be palpable below the gastrocnemius muscle in some slender or muscular patients. Other superficial veins above the feet are usually not palpable even after prolonged standing.

Currently utilized technologies such as duplex imaging have revealed that the GSV is often not the refluxing vessel causing varicosities. Accessory veins, circumflex veins, or even small groin veins, such as the superficial epigastric vein, may be the source. It should be emphasized that ultrasound technicians are often unfamiliar with superficial venous anatomy and its many variations. The treating physician must therefore be self-sufficient with regard to handling an ultrasound probe and recognizing the nuances of venous anatomy. The diagnosis of varicose veins is confirmed by the presence of venous reflux, which is diagnosed by duplex ultrasound as retrograde or reversed flow of greater than 0.5 second duration.^{41,42}

SCLEROSANTS AND SCLEROTHERAPY

The most common agents used in the treatment of varicose veins are sodium tetradecyl sulfate (STS), polidocanol, glycerin, and hypertonic saline. These substances cause endothelial damage by their actions as either osmotic or detergent agents. Osmotic agents achieve their effect by dehydrating endothelial cells through osmosis. Detergents are surface-active agents which damage the endothelium by interfering with cell membrane lipids.⁴³ In

vitro, detergent agents also exhibit procoagulant activity at lower concentrations, and anticoagulant activity in higher concentrations.⁴⁴ When comparing the two agents in terms of short-term success of sclerotherapy for varicosities, several systematic reviews have failed to support the use of one sclerosant over another (Table 72-2).⁴⁵⁻⁴⁷

Table 72-2. Concentrations of Sclerosants According to Vessel Diameter

Type of Varicose Veins	Polidocanol (Pol) Liquid	Sotradecol (STS) Liquid	Polidocanol (Pol) Foam	Sotradecol (STS) Foam
Small varices up to 4-mm diameter, visual- or duplex-guided injections (subdermal veins)	0.5–1% Up to 1 mL per injection point	0.25–0.5% Up to 1 mL per injection point	0.5% Up to 1 mL per injection point	0.25% Up to 1 mL per injection point
4–6-mm diameter extrafascial varices, under duplex guidance	1–2% Up to 1 mL per injection point	1–2% Up to 1 mL per injection point	1–2% Up to 2 mL per injection point, compress and massage to fill desired network, and trigger spasm	0.5–1.5% Up to 2 mL per injection point, compress and massage to fill desired network, and trigger spasm

STS is the most commonly studied sclerosant.⁴⁵ The maximum recommended dosage is 10 mL of a 3% solution in the United States and Canada, but the volume used varies worldwide depending on formulation. Dilutions between 0.1% and 3.0% are used depending upon the size of the vein treated; narrower diameter veins are treated with lower concentrations. A systematic review comparing various sclerotherapy agents for the treatment of small varicosities found that STS was more likely to cause adverse reactions at a concentration of 1% compared with polidocanol at 0.5%.^{47,48}

Polidocanol, also known as aethoxysklerol, is another detergent sclerosant available for commercial use in the United States, where it is marketed as Asclera®. The maximum dosage is dependent upon the weight of the patient. Dilutions between 0.25% and 5% are used depending on the size of the vein. In a systematic review comparing various sclerotherapy agents for the treatment of small varicosities, polidocanol was no more painful than placebo.⁴⁷

Hypertonic saline is the most commonly used osmotic agent for lower extremity sclerotherapy. The dilution used to treat lower extremity vessels ranges from 11.7% to 23.4%. Hypertonic saline (20%) mixed with heparin 100 units/mL constitutes Heparsal. Hypertonic saline is frequently mixed with local anesthetic to reduce the pain associated with injection (e.g., 20% saline plus 2% lidocaine).

Chromated glycerin (e.g., Chromex®, Skermo®) is a potent osmotic agent with dilutions that range from 25% to 72%. The maximum recommended amount per session is 10 mL.⁴⁹ While very popular worldwide, it is not commercially available in the United States.

Liquid sclerotherapy can be used to treat telangiectasias, reticular veins, small nonsaphenous varicose veins (<5 mm), residual or recurrent varicosities following endovenous ablation or surgery, and perforator veins.^{45,50} Liquid injection sclerotherapy is the gold standard for the treatment of the majority of lower extremity varicosities as the results are usually superior to those of cutaneous laser/light therapy.

When vessels are treated sequentially from deep to superficial and from larger to smaller veins, over 90% of vessels can be successfully treated. Due to the risk of longstanding hypopigmentation from laser and light treatments, liquid sclerotherapy is a more appropriate choice for patients with Fitzpatrick skin types IV, V, and VI. Laser/light treatments are recommended for patients who have failed sclerotherapy or experienced a poor outcome, patients with postsclerotherapy matting, needle-phobic patients, and patients allergic to sclerosant agents. Laser/light treatment is also preferred for vessels located at or below the ankle regions, which are more prone to ulceration with sclerotherapy.

Sclerosant foams were developed from liquid detergent sclerosant agents to increase the surface area of exposure, and are more commonly used for the treatment of larger varicosities.⁵¹ The foam can be produced manually just prior to injection using the Tessari method (Fig. 72-4).¹⁹ Foam prepared according to the Tessari technique has a half-life of approximately 90 seconds. Thus, the procedure should be completed within 1 minute, before the foam separates. An alternative consists of a product that dispenses a low-nitrogen gas and sclerosant liquid under pressure to produce polidocanol foam with appreciably smaller and consistently sized bubbles compared with a foam/air mixture made by hand.⁵² Sclerosant foam is echogenic due to the tiny air bubbles in the foam, which are easily seen with duplex ultrasound. The expanded volume of the foam compared with liquid agents provides more surface contact, a more uniform vessel closure, and permits the use of smaller volumes of sclerosant. In principle, all calibers of veins are suitable for foam sclerotherapy; however, foams are not generally used for the treatment of telangiectasias or reticular veins because there is no significant

advantage over liquid sclerotherapy in small vessels and, therefore, ultrasound-guided foam sclerotherapy (UGFS) is predominantly used for the treatment of saphenous incompetence (great or small) and incompetent perforating veins (Fig. 72-3).⁵¹



Figure 72-4. Tessari method.

PREOPERATIVE EVALUATION

Prior to the procedure, a careful review of the patient's medical file, including personal and family medical history, current medical treatments, previous phlebo-surgical and sclerosing treatments and outcomes, allergies, and contraindications should be made. Review of complete and recent duplex ultrasound scanning of both limbs, including superficial, deep, and perforating veins, and the patient's signed informed consent forms should also be made.

TECHNIQUE

Liquid sclerotherapy session

- Position the patient on the table:
 - Half-sitting for treatment on the anterior aspect of limb.
 - Prone for treatment of the posterior leg.
 - On the side for lateral and medially located lesions.
- Prepare the skin with alcohol or chlorhexidine.
- Don new gloves.
- Prepare syringes and needles for the tray:
 - For subcutaneous varicose veins up to 4 mm: 2.5-mL syringe, 25- to 28-gauge needle, liquid polidocanol 0.5% to 2%, or STS 0.5% to 1%. If necessary: foamed polidocanol 0.5% to 1%, STS 0.25% to 0.5%.
 - Larger varicose veins injected without duplex guidance: liquid polidocanol 1% to 3%, STS 1% to 3%. Preferably foam if no contraindication.
- Localize, puncture, and inject larger varices first, then reticular varices, and finally telangiectasias. Check appropriate needle tip placement by usual means (reflux of blood in the needle when aspirating, absence of visible or palpable bump or swelling at the injection site, blanching of catheterized veins). Use magnifying goggles, transillumination (Figs. 72-5 and 72-6), or other visualization devices when needed. Favor multiple injections of low volumes. In telangiectasias, avoid blanching areas bigger than 2.5×2.5 cm from a single injection point.

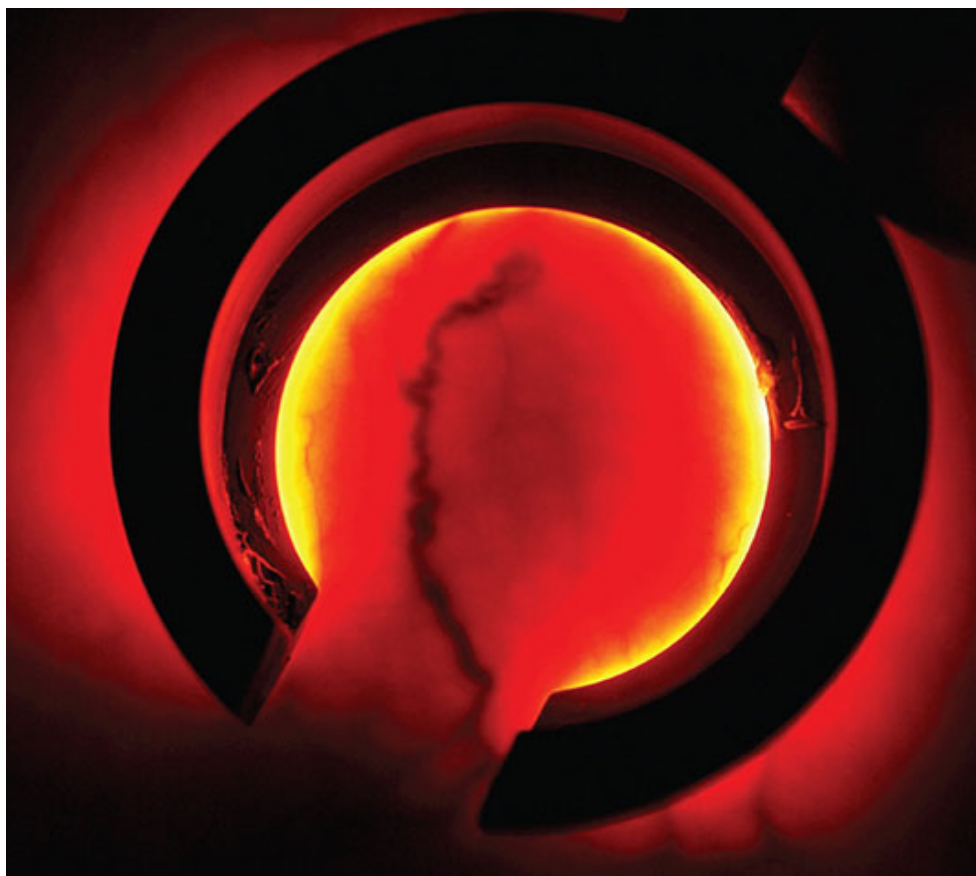


Figure 72-5. Handheld transilluminator to facilitate vein access and treatment.



Figure 72-6. Handheld transilluminator used during sclerotherapy.

- Report injection sites, volume used, concentrations, immediate outcomes, and side effects in patient's chart.
- Microthrombectomy of previously treated varicose veins may be necessary during the session (Figs. 72.7, 72.8 and 72.9).



Figure 72-7. A 40-year-old male in good physical condition and an occupation that involved prolonged standing presented with a varicose vein on his right leg. Symptoms included pain and “heaviness” that intensified at night and during warm weather.



Figure 72-8. Duplex ultrasound did not reveal reflux, thus liquid sclerotherapy with polidocanol was prescribed.



Figure 72-9. A 2-year follow-up showed complete clearance.

Foam sclerotherapy session

- Locate target vein in longitudinal or transverse view according to local conditions and preferred technique. Measure depth to compute needle length, measure diameter to estimate volumes to inject.
- Prepare foam with two syringes and a female–female connector (Tessari method):
 - In one 2.5-mL syringe aspirate 2 mL of gas: room air, sterile air, other gas mix (if using 5-mL syringes aspirate 4 mL of gas).
 - In the other syringe, aspirate 0.5 mL of sclerosing agent (polidocanol or STS) at the desired concentration (0.5–3%).
 - Unite syringes with connector.
 - Pass contents back and forth from one syringe to the other 20 times. Foam is now ready, and must be used in less than 2 minutes (Figs. 72-10 and 72-11).



Figure 72-10. Preparation of tray for foam sclerotherapy.



Figure 72-11. Preparation of foam sclerosant.

- If open vein access is ready, connect foam syringe to access, aspirate to check blood reflux, inject a few bubbles, check their presence in vein lumen on duplex screen, and proceed to injection of desired amount of foam according to planned protocol (predetermined volume or sufficient volume to induce venous spasm).
- If no open vein access has been inserted previously, attach a needle to the foam syringe (no smaller than 25 gauge, sufficient length is 2 to 3 times the depth of the vein). Puncture the vein and check presence of tip in the middle of the vein lumen. Aspirate to verify blood reflux in syringe, inject a few bubbles to verify their presence on duplex screen, and proceed to inject the desired volume.
- Check progression of sclerosing foam in target varices. If necessary, massage foam into remote veins, observe venous spasm, and observe progression of scattered bubbles into perforating and deep system if any.
- Report injection sites, volumes, concentrations, diffusion, immediate outcomes, side effects, and all relevant information in patient's chart ([Figs. 72-12 and 72-13](#)).



Figure 72-12. A 42-year-old woman presented with networked varicose veins in her left leg after her third pregnancy. She had an unremarkable medical history and took no medications. Her main concern was the aesthetic appearance. As part of the routine investigation protocol, a thorough lower limb duplex venous mapping scan was performed that revealed no great or small saphenous vein incompetence. The patient was treated conservatively with ultrasound-guided foam sclerotherapy (UGFS) with sodium tetradecyl sulfate (STS) solution foamed with air (three parts air and one part 1.5% STS). Six milliliters foam utilizing six separated injections of 1-mL foam were injected in the leg vein. Class 2 compression stockings were applied and the patient was asked to wear a firm pair of cotton underwear and walk for half an hour immediately after completion of the treatment. She returned 1 week post treatment for a left lower limb follow-up duplex scan, which demonstrated that all the treated veins were well sclerosed and the deep veins were patent with normal flows. The patient did not report any adverse symptoms.



Figure 72-13. Subject post sclerotherapy session.

POSTOPERATIVE CARE

After treatment of large varicose veins by any method, a 30- to 40-mm Hg gradient compression stocking is applied, and patients are instructed to maintain or increase their normal activity levels (Fig. 72-14). Many clinicians also recommend the use of gradient compression stockings even after treatment of smaller varicose veins. In a randomized trial of patients undergoing foam sclerotherapy for primary uncomplicated varicose veins, no significant difference was noted in vein occlusion, phlebitis, skin discoloration, or pain at 2 and 6 weeks with the two techniques.⁵³ Ace wraps and other long-stretch bandages should not be used. These elastic bandages fail to maintain adequate compression for more than a few hours. They often slip or are misapplied by patients, with a resulting tourniquet effect that

causes distal swelling and increases the risk of DVT. Activity is particularly important after treatment by any technique, as all treatments for varicose disease have the potential to increase the risk of DVT. Activity is a strong protective factor against venous stasis. Indeed, many venous specialists will not treat a patient who is unable to remain active following treatment.



Figure 72-14. Compression stockings for sclerotherapy.

COMPLICATIONS

Superficial thrombophlebitis

A mild inflammatory response is expected after sclerotherapy, and some patients may have urticaria at the site of injection. A more intense superficial thrombophlebitis with erythema, warmth, and pain can extend to veins neighboring the injection site.

Deep vein thrombosis

A systematic review of foam sclerotherapy reported DVT in 0.02% to 5.7% of patients.⁵⁴ Although DVT can occur after sclerotherapy of telangiectasias, it is more likely to occur after sclerotherapy of the saphenous veins.⁵⁵ Popliteal vein thrombosis has been reported with foam sclerotherapy of the small saphenous vein.^{56,57} Patients are diagnosed and treated for deep venous thrombosis following standard protocols.

Visual and other neurologic disturbances

Visual or neurologic disturbance is uncommon during or following sclerotherapy. In a systematic review, the incidence of visual disturbance following sclerotherapy ranged from 0.09% to 2%.⁵⁸ These disturbances are usually transient; permanent deficits are rare.⁵⁴ Symptoms include visual disturbance (scotoma), migraine-like headache, and neurologic deficits. These appear to be more common with foam compared with liquid sclerotherapy.⁵⁹ Visual disturbances reported following sclerotherapy of telangiectasias and reticular veins are strongly associated with the use of air-block and foam techniques, suggesting that the etiology is air microembolization. Most visual disturbances occur during or immediately after the procedure when the patient ambulates, possibly due to rising microbubbles in the bloodstream. In one study, 20 of 12,173 patients (0.16%) treated with sclerotherapy experienced visual disturbances, 70% of which were following sclerotherapy of small varicosities.⁵⁵ Visual disturbances were associated with nausea, headache, or vasovagal episodes; all cases regressed spontaneously.

During foam sclerotherapy of the GSV, microbubbles can be detected in the right heart and pulmonary circulation, and in patients with a patent

foramen ovale, in the left heart as well.³⁸ Coughing following foam sclerotherapy has been attributed to air microembolization into the pulmonary circulation. In a prospective study of 33 patients, cardiac echo was performed during foam sclerotherapy with cardiac microemboli detected in every patient studied. Microemboli were also seen in the left ventricle of five patients, and each was subsequently found to have a patent foramen ovale; however, none of these patients experienced neurologic symptoms.³⁸ Given the significant prevalence (25–30%) of patent foramen ovale in the general population, it is apparent that the incidence of significant neurologic sequelae following foam sclerotherapy is low.

COMBINATION WITH LASERS

Several studies have demonstrated the clinical superiority and patient preference of sclerotherapy compared with laser therapy for the treatment of varicosities.⁶⁰ However, given the need for repeat sclerotherapy sessions in order to achieve complete clearance of varicose veins, combination therapy with lasers has been evaluated to improve clinical results while minimizing patient discomfort and time investment. In an early study, combination treatment with pulsed dye laser (585 nm) followed by sclerotherapy with polidocanol (0.1–0.25 mL per injection site) in 30 female patients with varicosities showed that the treatments were efficacious for the larger varicose veins rather than for smaller vessels.⁶¹ In a later study of 14 patients with leg varicosities that were treated with either long-pulsed Nd:YAG alone, sclerotherapy alone, laser then sclerotherapy, or sclerotherapy then laser, results demonstrated that combination approaches may increase response to treatment.⁶² The best sequence appeared to be sclerotherapy followed by laser, as this demonstrated a higher clearance compared to laser then sclerotherapy. A recent randomized, polidocanol-controlled clinical trial comparing the results between 79 legs treated with polidocanol and 517 treated with polidocanol together with long-pulsed Nd:YAG laser, showed that the combination treatment was much more effective than polidocanol microfoam alone in clearing varicosities with a diameter under 4 mm. The 3-year follow-up showed clearing percentages of 89% (Class I veins), 94% (Class II veins), and 95% (Class III veins) in the combination treatment

cohort in comparison to 15%, 18%, and 17%, when only polidocanol was applied.⁶³

CONCLUSIONS

Sclerotherapy is a highly effective technique for varicose vein management, and can lead to marked cosmetic and quality-of-life improvement. Attention to detail in the pre-, intra-, and postoperative periods may improve outcomes. Smaller vessels may be treated with liquid sclerosants, while foam approaches are helpful for the treatment of larger vessels. Combination approaches with laser and sclerotherapy are very promising.

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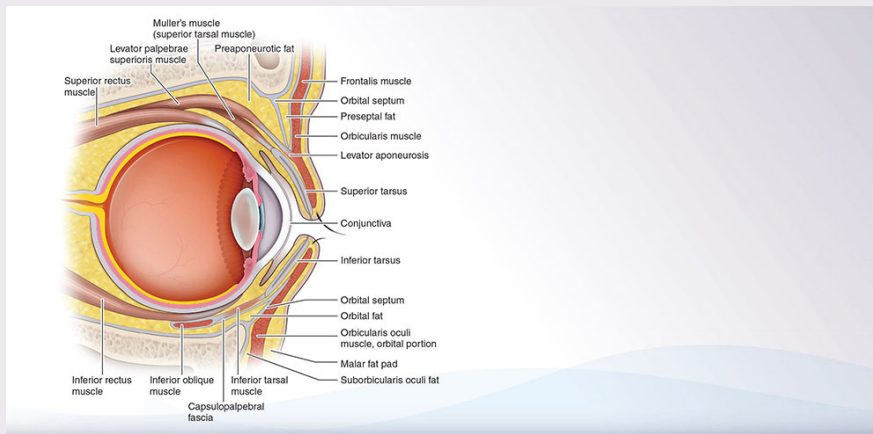
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CHAPTER 73 Blepharoplasty

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SUMMARY

- Blepharoplasty is the most frequently performed facial aesthetic surgical procedure in the United States.
- Blepharoplasty is primarily used to treat dermatochalasis, and both upper and lower blepharoplasty result in a more alert and youthful appearance.
- Anesthesia options include local anesthesia, local anesthesia with IV sedation, and general anesthesia.

Beginner Tips



- Be sure to distinguish between eyelid ptosis, brow ptosis, and dermatochalasis.
- Upper lid blepharoplasty with en bloc excision of upper lid skin, orbicularis oculi muscle, and/or orbital fat is the gold standard for the correction of dermatochalasis.
- The consequences of aggressive skin removal are more difficult to correct than the consequences of managing residual skin excess.

Expert Tips



- Superior sulcus hollowing is a common postoperative complication, prompting a recent shift toward volume preservation in upper lid blepharoplasty.
- Lid malposition seems to occur less frequently with concomitant canthal suspension.
- Instead of fat excision, many now advocate for fat preservation and repositioning as a more effective means of lower lid and mid-face rejuvenation.

Don't Forget!



- Negative-vector patients (those with prominent eyes without bony support) are at increased risk of ectropion and dry eye postoperatively.
- There is significant variation in technique options, though what the surgeon knows and is most comfortable with might be more important than the actual choice of technique and surgical approach.

Pitfalls and Cautions



- Brow ptosis should be distinguished from dermatochalasis. If both problems are present and blepharoplasty alone is performed, the degree of brow ptosis may be worsened.
- With transcutaneous lower eyelid blepharoplasty, lower eyelid ectropion and retraction can occur in up to 30% of cases.
- For lower eyelid blepharoplasty, avoid excessive skin removal; usually only 2 mm of skin excision is required at the most.

Patient Education Points



- Controlling patient expectations is critical.
- If the patient does not want brow surgery, they should be made aware that the degree of brow ptosis could worsen after isolated blepharoplasty, creating the appearance of excess upper lid skin from the descended brow.
- Counsel patients that the need for additional skin removal should not adversely influence an overall successful cosmetic outcome.

Billing Pearls



- Most insurance companies require clinical photographs and visual field images for preapproval purposes.
- Aesthetic blepharoplasty patients may benefit from combining blepharoplasty with other procedures, and sometimes they can see cost savings by doing this.

CHAPTER 73 Blepharoplasty

INTRODUCTION

Blepharoplasty is the most common aesthetic surgical procedure performed on the face in the United States,¹ and its goal is to restore a youthful contour to the eyelids and midface. Upper and lower eyelid blepharoplasty are two distinct procedures with distinct aesthetic aims. Upper blepharoplasty is performed to address excess skin, asymmetric eyelid creases, fat or lacrimal gland prolapse, and/or sulcus hollowing. Lower blepharoplasty is performed to address the orbitomalar region, including tear-trough deformity and/or prominence of the lid–cheek junction. While an excellent cosmetic outcome is always attempted, patients may seek blepharoplasty surgery for functional, cosmetic, or a combination of reasons.

The most commonly used word for excess eyelid skin is *dermatochalasis*, which refers to the fine wrinkling and loosening of eyelid skin that occurs with age (Fig. 73-1). *Blepharochalasis* is another frequently used term, though it more accurately refers to a syndrome of cyclic eyelid edema that usually occurs in younger patients (Fig. 73-2). Blepharochalasis can lead to thinning of eyelid skin, atrophy or prominence of the eyelid fat pads (depending on the phase of the condition), ptosis, and increased eyelid laxity.² *Steatoblepharon* is commonly associated with dermatochalasis, and describes prominent upper and/or lower eyelid fat pads (Fig. 73-3). It is important to distinguish between dermatochalasis, eyelid ptosis, and brow ptosis. Upper eyelid ptosis occurs when the eyelid falls lower than its normal position, which is usually 2 to 3 mm above the superior corneal limbus in central gaze (Fig. 73-4).³ When the brow falls below the level of the superior orbital rim, a diagnosis of brow ptosis is made (Fig. 73-5). This

may accentuate the appearance of dermatochalasis, and can be addressed simultaneously with upper blepharoplasty.



Figure 73-1. Bilateral upper eyelid dermatochalasis.



Figure 73-2. Bilateral blepharochalasis.



Figure 73-3. Bilateral steatoblepharon.



Figure 73-4. Right upper eyelid ptosis.



Figure 73-5. Bilateral brow ptosis and right lower eyelid ectropion.

ANATOMY

A strong grasp of periorbital anatomy is important in order to execute an appropriate surgical plan for patients undergoing eyelid surgery. The upper eyelid, moving from superficial to deep, is comprised of skin and orbicularis oculi muscle. The orbicularis muscle is the main protractor, or closer, of the eyelid and has three different functional segments ([Fig. 73-6](#)). The pretarsal and preseptal orbicularis muscles (referred to as palpebral orbicularis as a unit) allow for involuntary blinking. The pretarsal orbicularis muscle originates from the posterior lacrimal crest and the anterior limb of the medial canthal tendon. The preseptal portion of the muscle originates from the upper and lower borders of the medial canthal tendon.⁴ Sparing of these structures during upper eyelid blepharoplasty may reduce postoperative complications such as dry eye and poor lid closure, as well as preserve fullness to the upper lid.^{5,6} The orbital orbicularis muscle encircles the orbital rim and originates from the medial canthal tendon, frontal process of the maxilla, and the orbital process of the frontal bone.⁷ Orbital orbicularis muscle is responsible for forced eyelid closure.

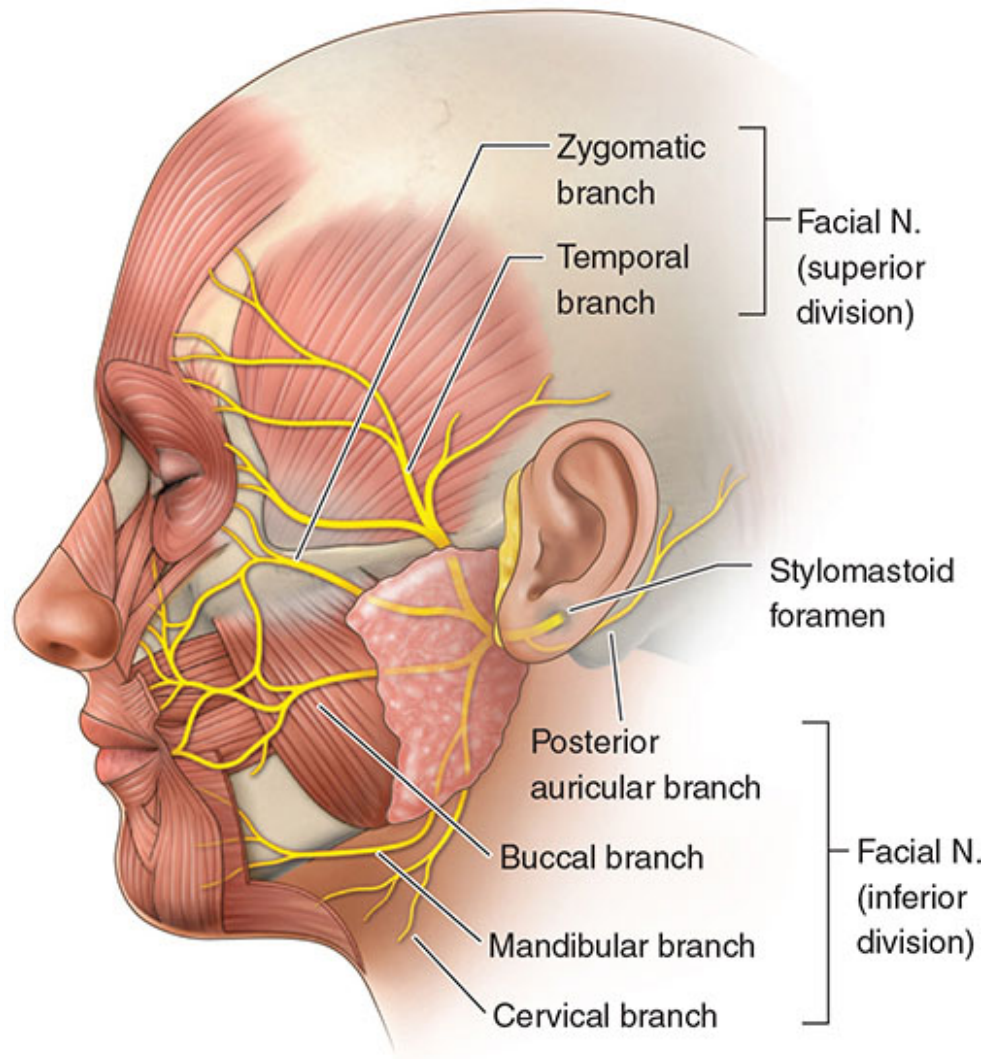


Figure 73-6. The facial nerve innervates the orbicularis oculi muscle.

Posterior to the pretarsal orbicularis lies the tarsus, which is 8 to 10 mm in height in the upper lid and 3 to 4 mm in the lower lid (Fig. 73-7). Superior to the tarsus and deep to the orbicularis muscle is the orbital septum, which is a fibrous, avascular structure that originates from the periosteum of the superior orbital rim (arcus marginalis) and inserts onto the superior aspect of tarsus. This structure delineates the pre- and postseptal spaces of the eyelid and orbit.

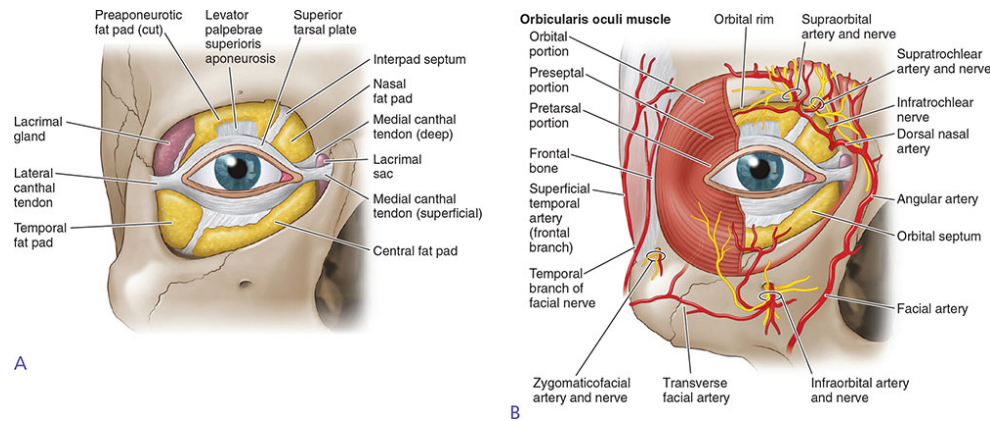


Figure 73-7. Eyelid anatomy.

Beneath the orbital septum are the nasal and central upper eyelid fat pads, as well as the orbital lobe of the lacrimal gland laterally. The central fat pad is also referred to as the preaponeurotic fat compartment. In addition to their location, these two fat compartments can be distinguished by their color; the nasal pad is pale yellow or white while the central fat pad is more yellow.⁸ With aging, the nasal fat pad is most likely to become visible through attenuated septum,⁸ and it can be debulked at the time of blepharoplasty surgery. More recently, the tendency has shifted to preservation of upper eyelid fat, especially with regard to the central compartment where fat can be mobilized and preserved.⁹

The lacrimal gland occupies the most lateral postseptal compartment in the upper eyelid. Composed of a larger orbital lobe and a smaller palpebral lobe, it resides in a fossa of the frontal bone in the superotemporal orbit (Fig. 73-8). The palpebral lobe is often visible with eversion of the upper eyelid. However, with age, it is the orbital lobe that may prolapse anteriorly and manifest as a fullness in the lateral upper eyelid (Fig. 73-9). Other, noncompartmentalized fat may also contribute to lid fullness in the aging face, especially among Asians.¹⁰

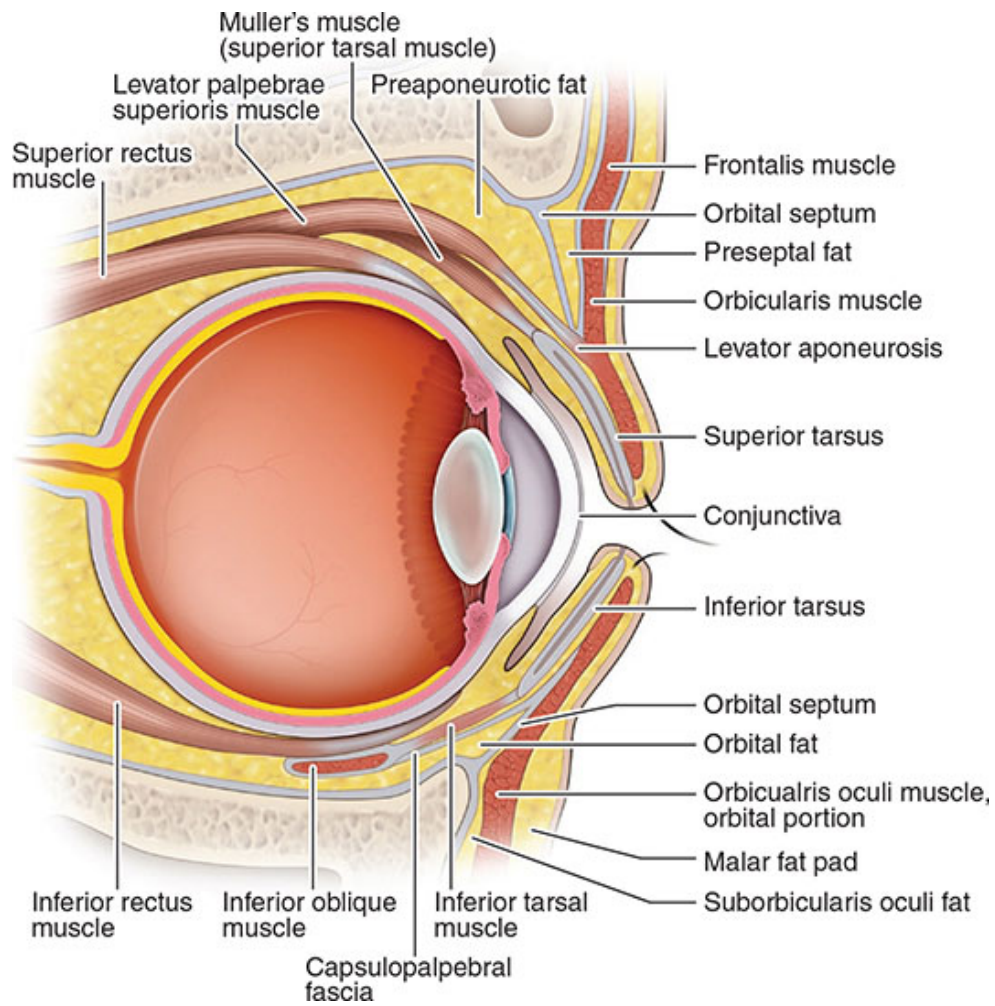


Figure 73-8. Upper and lower eyelid structures.



Figure 73-9. Unilateral lacrimal gland prolapse.

Deep to the upper eyelid fat compartment is the levator palpebrae superioris muscle. It arises from the periorbital lesser wing of the sphenoid bone at the orbital apex, just outside the Annulus of Zinn. As the levator muscle extends anteriorly within the orbit, it transitions to become an aponeurosis at Whitnall's ligament and sharply changes to a more inferior direction. It then divides into an anterior and posterior portion within the eyelid. The posterior portion inserts on the anterior aspect of tarsus, while the anterior portion projects to pretarsal orbicularis muscle and skin, contributing to the formation of the upper eyelid, or pretarsal, crease.

The position of the lid crease varies with gender, ethnicity, and age. In Caucasians, the upper eyelid crease is usually found 8 to 9 mm above the superior lash line in men and 9 to 11 mm above the lash line in women.¹¹ In Asians, the lid crease may be absent or very low because of a more inferior insertion of septum and/or absent insertion of the levator aponeurosis into the dermis.^{12–14} The lid crease may be higher or absent in patients with aponeurotic or congenital ptosis. Muller's muscle originates on the undersurface of the levator muscle and inserts on the superior margin of tarsus. Both the levator and Muller's muscles function as eyelid retractors, and are separated from each other by the rich vascular plexus of the peripheral arterial arcade.

Since the eyebrow and upper eyelid are often considered as a continuum, the position of the brow is of vital component in the assessment of the upper eyelid.¹⁵ In general, the highest peak of the brow is at the central and lateral junction, corresponding to the lateral corneal limbus. In women, a youthful brow resides 0.5 to 1 cm above the superior orbital rim. In men, the youthful brow position is lower, residing at or slightly above the orbital rim, and the brow contour is more flat and less arched.¹⁶ Depending on the degree of sub-brow fat atrophy, aging patients may present with significant lateral hooding in addition to dermatochalasis.

In many ways, lower eyelid anatomy is similar to the anatomy of the upper eyelid, with a few important differences. Moving from superficial to deep, thin skin is found above the palpebral and orbital components of orbicularis oculi muscle, and the septum underlies the muscle. The lower lid retractors are less distinct than those in the upper lid and are comprised of (a) the capsulopalpebral fascia, which originates from terminal fibers of the inferior rectus muscle, and (b) the inferior tarsal muscle, which originates from the posterior aspect of the capsulopalpebral fascia. The capsulopalpebral fascia and inferior tarsal muscle are analogous to the levator aponeurosis and Muller's muscle (otherwise known as the superior tarsal muscle), respectively. After fusing with the orbital septum, which originates from the periosteum of the infraorbital rim at the arcus marginalis, the lower lid retractors insert on the inferior margin of tarsus.

Three fat compartments are found in the lower eyelid, rather than two, as are found in the upper eyelid (Fig. 73-7). The medial, central, and lateral fat pads reside posterior to the orbital septum. The inferior oblique muscle is found between the medial and central fat pads, while an extension of Lockwood's ligament, the suspensory ligament of the lower eyelid, is found between the central and lateral fat pads.¹⁷ In youth, the orbital septum and Lockwood's suspensory ligament have strong tone, maintaining the fat pads posterior to a vertical vector connecting the lid margin to the orbital rim. The configuration of the palpebral fissure is maintained by the medial and lateral canthal tendons, which are a blending of attachments from the orbicularis muscle and tarsus that fuse onto orbital periosteum. Tightening of the lateral canthal tendon may be performed at the time of lower lid blepharoplasty to reduce the likelihood of postsurgical ectropion.

Unique to the lower lid are the orbital retaining ligament and the tear trough. The orbital retaining ligament (also referred to as the orbitomalar ligament)¹⁸ originates from the arcus marginalis as a condensation of connective tissue that divides the orbital orbicularis from the preseptal orbicularis and attaches to the dermis. This multi-laminate ligament suspends the malar fat pad.^{19–21} The tear trough is a dense attachment of the orbicularis to the anterior maxillary crest seen medial to the mid-pupillary line. Also known as the nasojugal fold, this concavity is relatively devoid of suborbicularis fat. Immediately inferior to the tear trough are the attachments of the levator labii superioris and the levator alaeque nasae.²⁰

The ligament and/or its attachments to skin may attenuate over time and give rise to descent of the malar fat pad. Ptosis of the malar fat pad gives rise to both the so-called concavity convexity deformity at the lid cheek junction (palpebromalar groove) and to the apparent lower eyelid lengthening seen with aging.²² The concavity seen in aging represents an area of soft-tissue deficit between the relative convexities of the pseudoherniated fat of the lower eyelid and the ptotic malar fat pad.

Descent of the midface gives rise to the inverted V deformity, as the aged ptotic and atrophic malar fat pad appears suspended to the orbital rim and hangs from the tear trough. The V deformity is thought to arise as a result of several descending forces in the lower lid and midface. First, there is stretching of the superficial muscular aponeurotic system (SMAS) in the lateral midface, allowing the malar fat and suborbicularis oculi fat (SOOF) to descend inferiorly. Second, the nasojugal fold medially deepens and becomes more pronounced. These two medial and lateral forces contribute to the appearance of an inverted V-shaped deformity in the lower lid.

Elastic and smooth skin contributes to a youthful eyelid appearance. Important skin changes of the aging eyelid include thinning, loss of elasticity, hyperpigmentation, and actinic changes, as well as increased laxity of the orbicularis muscle and canthal tendons.^{22,23} Changes in orbicularis muscle tone and decreased skin elasticity may contribute to the increased lower eyelid length commonly seen in the aging face.²⁴ Bone structure also changes with age, and atrophy of the orbital rim may contribute to the apparent changes related to volume loss in the aging face.²⁵

EVALUATION

Blepharoplasty is a procedure of nuance, and preoperative evaluation sets the groundwork for effective surgical intervention. An understanding of the typical changes seen in the aging face is important (Fig. 73-10).



Figure 73-10. Changes of the aging face.

The first step in the evaluation is the history. The surgeon should gain an understanding of what is most bothersome to the patient about their eyelid and facial appearance. For example, the surgeon must understand if their patient's dissatisfaction lies in excess skin ("bags"), hyperpigmentation

(“circles”), fat prolapse (“puffiness”), rhytides, and/or ptosis in order to generate a plan that will ultimately lead to patient satisfaction. A combination of these issues brings the patient to seek surgical intervention. Motivation for surgery should be discussed. Often a major event, such as the wedding, will affect the timing of surgery.

A complete past medical history should be obtained including any chronic illnesses such as hypertension, heart disease, diabetes, obesity, blood dyscrasias, thyroid disorders, and autoimmune conditions (especially those requiring immunosuppressive medications), all of which might increase anesthesia risk, bleeding risk, and postoperative wound healing time. Active medications should be recorded with particular attention to those that may affect clotting, such as dietary supplements (i.e., fish oil, garlic, ginko, ginger, ginseng, glucosamine), over-the-counter pain medications (i.e., Advil, Aleve, Aspirin), and anticoagulants. These should all be stopped at least 2 weeks preoperatively.²⁶ Medication allergies should also be documented. A complete social history should be obtained, including smoking, alcohol intake, and illicit drug use, all of which may lead to poor wound healing or poor perioperative compliance. Other important aspects of the social history include patient occupation and job requirements, since time off from work will be necessary.

A detailed ocular and periorbital history is necessary for appropriate surgical counseling, including prior oculofacial, refractive, or orbital surgery, trauma, glaucoma, epiphora, contact lens use, and dry eye syndrome. LASIK (laser assisted in situ keratomileusis), a refractive procedure performed for the correction of myopia or hyperopia, is a specific consideration. Patients who have had LASIK surgery often have dry eye and diminished corneal sensation. LASIK surgery performed soon after blepharoplasty and blepharoplasty performed soon after LASIK surgery have resulted in corneal complications.²⁷ As a result, waiting a period of at least 1 year between these surgeries may be wise. Dry eye is common in the general population, occurring in up to 5% to 15% of people.²⁸ Symptoms include foreign-body sensation, blurred vision, photophobia, headache, itching, tearing, discharge, and eye redness.²⁹ Schirmer’s strip testing is used to quantify tear production (Fig. 73-11). Fluorescein and lissamine green dye staining are used to highlight areas of corneal or conjunctival de-epithelialization from dry eye syndrome (Fig. 73-12). A high incidence of

postoperative dry eye symptoms occur after blepharoplasty, and patients should be made aware of this risk as part of the preoperative discussion. However, if symptoms of dry eye are present, one may consider referral to an ophthalmologist for further evaluation before proceeding with blepharoplasty, and full informed consent with the patient regarding the risks of exacerbating dry eye and conservative surgery (or no surgery) is recommended in this subgroup.



Figure 73-11. Shirmer's strip testing for dry eye evaluation.

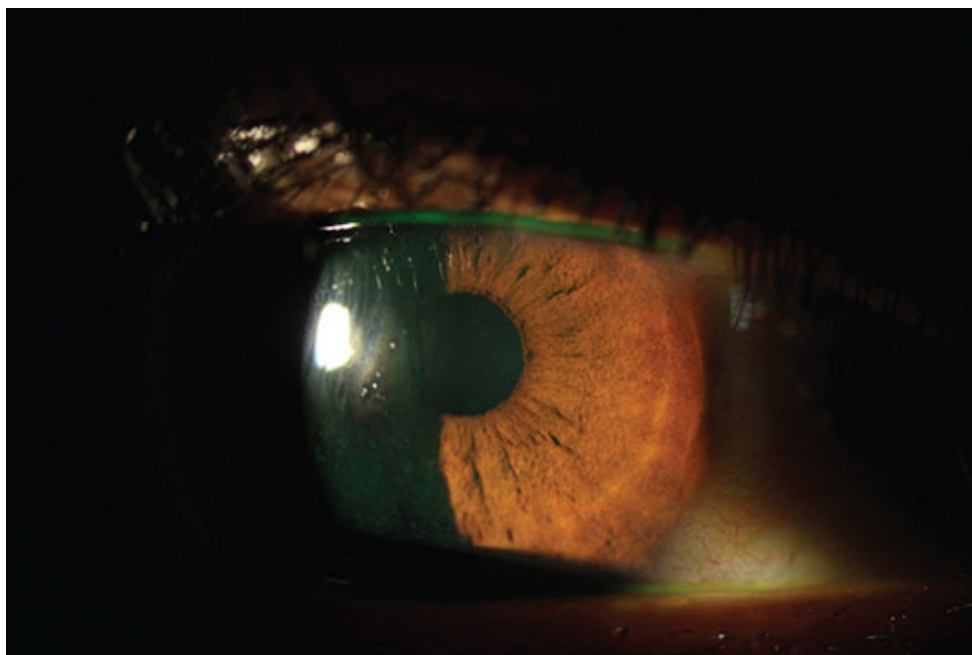


Figure 73-12. Punctate epithelial fluorescein staining (green dots) on corneal surface in dry eye syndrome.

A general physical examination should be performed. Facial examination should include an overall assessment of skin, muscle, fat, middle lamella, and bone structure. It is important to distinguish between ptosis (drooping upper eyelid) and dermatochalasis (excess upper eyelid skin). An assessment of ptosis should take into account variations in eyelid height, such as level of alertness, pharmacologic agents, direction of gaze, size of globe, orbital volume, visual acuity, and extraocular muscle balance (position of the eye). If true ptosis is found to be present during the preoperative evaluation, consider referral to an ophthalmologist.

Brow ptosis should be distinguished from dermatochalasis. If both problems are present and blepharoplasty alone is performed, the degree of brow ptosis may be worsened. In such patients, a combined brow lift and blepharoplasty may be optimal. Additionally, the degree of eyebrow compensatory frontalis overaction should be noted. All patients have some degree of resting frontalis tone, and blepharoplasty may decrease frontalis muscle tone, resulting in brow descent and a postoperative surprise in lowered brow position.³⁰

In the general examination, the surgeon proceeds from external (skin) to internal (bone). The surgeon must carefully document the location of skin

excess. The degree of skin laxity should be noted, along with the amount of sun damage. A close evaluation of the skin should be performed, documenting the amount of sun damage and actinic changes, texture, and laxity. Skin texture should be optimized before blepharoplasty with an ideal skin care regimen. Similarly, eczema and rosacea should be treated beforehand to optimize surgical outcomes. When skin resurfacing is considered, skin type may be noted.³¹

Muscle tone should be evaluated, assessing the strength of lid closure and looking for the presence of festoons of the orbicularis. If there is any eyelid weakness or lagophthalmos (Fig. 73-13), a Bell's phenomenon should be recorded, as well as evidence of cranial nerve VII palsy or aberrant regeneration.

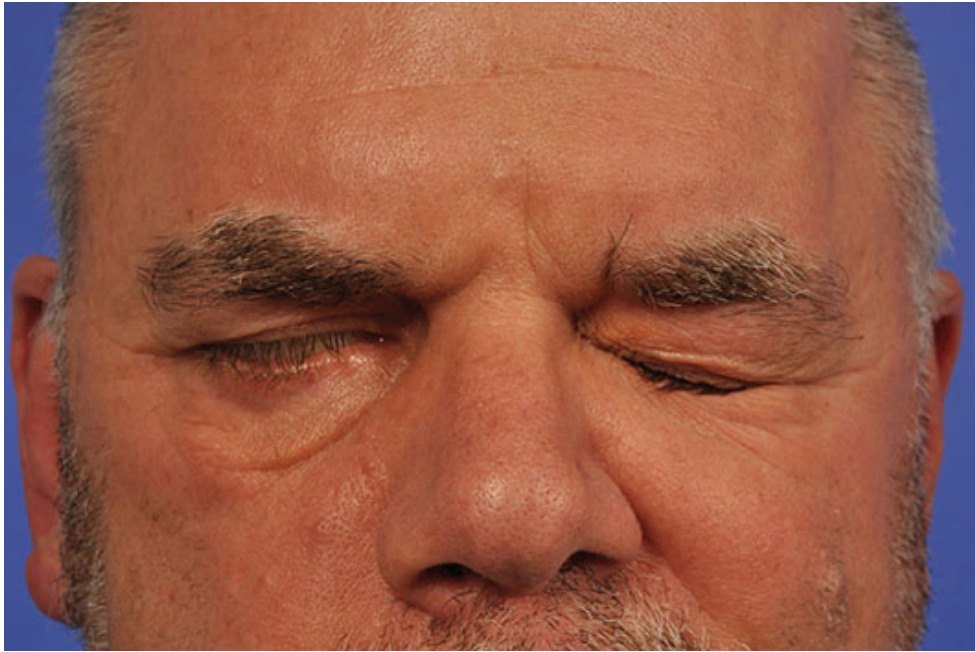


Figure 73-13. Unilateral lagophthalmos.

Volume excess in the upper and lower eyelids should be documented, with details about the relative location and amount, as well as volume deflation in the facial fat compartments. Ptosis of the lacrimal gland should be noted in the temporal upper eyelid, and must not be mistaken for fat excess (Fig. 73-9). In any patient with a prominent lacrimal gland, careful inspection of the area should be performed to make sure that there is not lacrimal gland

enlargement from an underlying neoplastic, inflammatory, or infectious process.

Atrophy and ptosis of the malar fat pad as well as submalar hollowing should also be noted. Asymmetry is the rule in most patients, and it is helpful during the preoperative evaluation to point this out so that the patient understands that these asymmetries will likely persist postoperatively.

When there is fat prolapse, the specific compartments that are prominent should be quantified from 1 to 3+, with the size of the small fingernail equaling one unit (Figs. 73-14 and 73-15).³² Areas of fat atrophy and hollowing may be noted in the tear trough region, cheek-malar groove, lateral brow, and temple area.



A



B





Figure 73-14. Mild (A), moderate (B), and severe (C) degrees of upper eyelid fat prolapse.

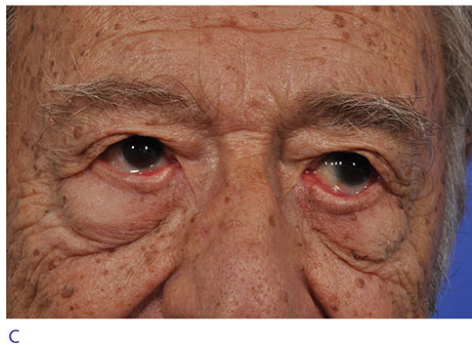


Figure 73-15. Mild (A), moderate (B), and severe (C) degrees of lower eyelid fat prolapse.

Lower lid festoons, or malar mounds, are redundant folds of loose skin, muscle, fat and edema that extend beyond the lateral cheek. The skin is occasionally pigmented in chronic cases. Their etiology is not entirely understood. Festoons may be caused by orbicularis muscle or orbitomalar ligament weakness, allowing skin, fat, and muscle to descend below the level of the orbital rim.³³ They may be more common in patients with thyroid eye disease, kidney disease, or lymphatic obstruction, and can be seen after eyelid or midface surgery.³³

Finally, the configuration of the eye within the bony orbit and its relationship to the inferior orbital rim can predictably determine whether a patient may be at high risk for ectropion and dry eye symptoms after surgery. Patients with prominent eyes without adequate bony support, so-called negative vector patients, are at risk to have these issues (Fig. 73-16). While this can be roughly predicted from a general examination, a Hertel exophthalmometer can be used to make a more objective determination (Fig. 73-17).³⁴



Figure 73-16. Negative eyelid vector. Note that the anterior surface of the cornea extends beyond the lower lid border.

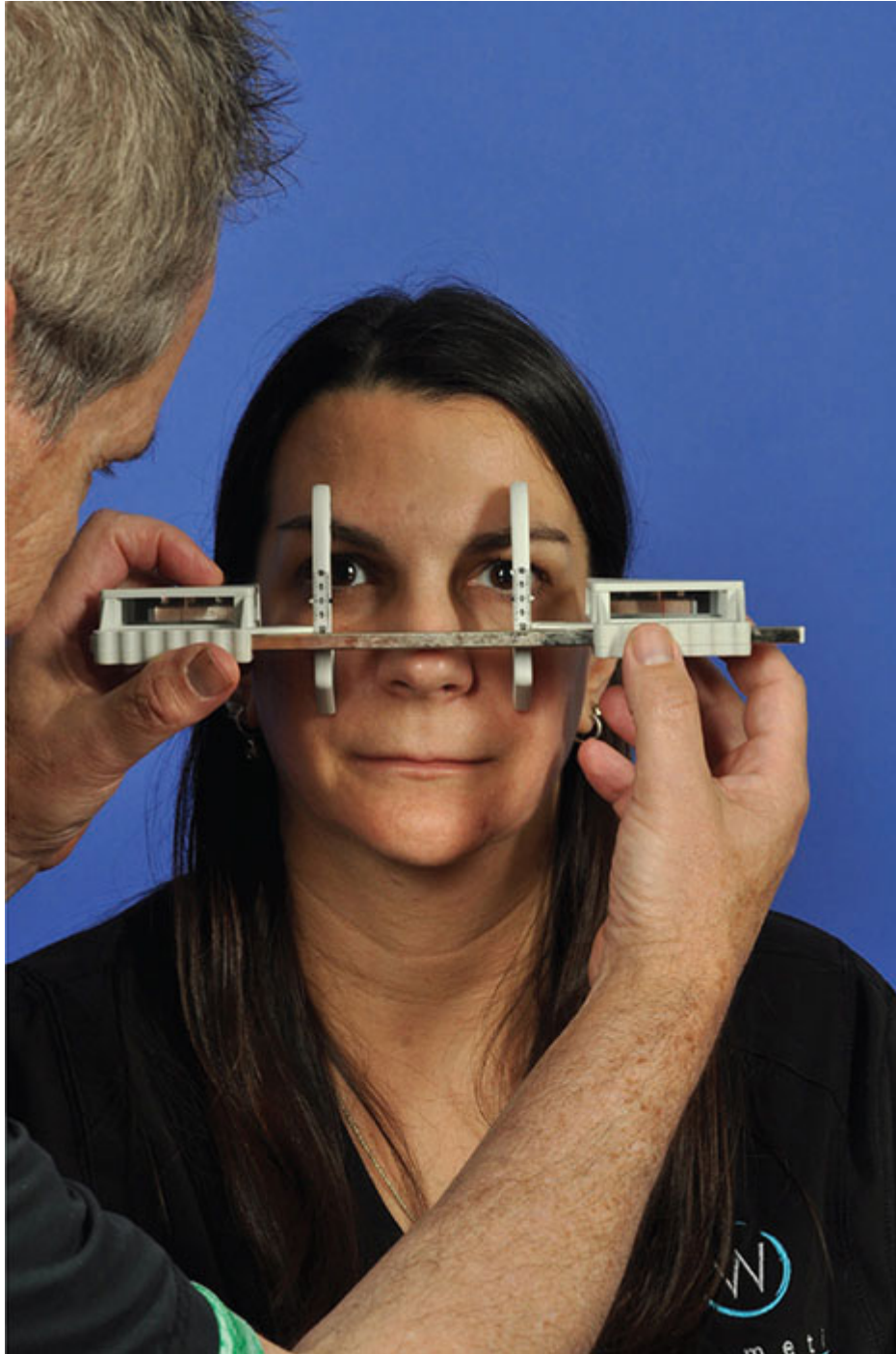


Figure 73-17. Hertel exophthalmometry testing.

The ophthalmic examination should always include a visual acuity measurement with the Snellen eye chart. Formal visual field testing may be necessary for insurance purposes. Evaluation of extraocular motility, including strabismus and pupillary light response should be performed.

Marginal reflex distances (distance from central pupillary light reflex to upper and lower lid margins) (Fig. 73-18), interpalpebral fissure height, levator function, and upper eyelid crease height should also be recorded. The strength of the orbicularis muscle and lower lid retractors should be assessed with the lower lid snap back test (normal is <1 second) (Fig. 73-19) and the eyelid distraction test (normal is when the lid does not distract more than 6 mm from the globe). The lateral canthal tendon is usually 2 mm higher than the medial canthal tendon (positive canthal tilt). A negative canthal tilt may be another sign of increased lid laxity.³⁴ In these cases, blepharoplasty should be performed with lateral canthopexy to prevent lid malposition postoperatively (i.e., ectropion).³⁵ Again, dry eye findings can be assessed by measuring tear secretion with Shirmers' testing and with ocular surface staining (lissamine green and fluorescein dye) of areas of de-epithelialization as viewed under the slit lamp.

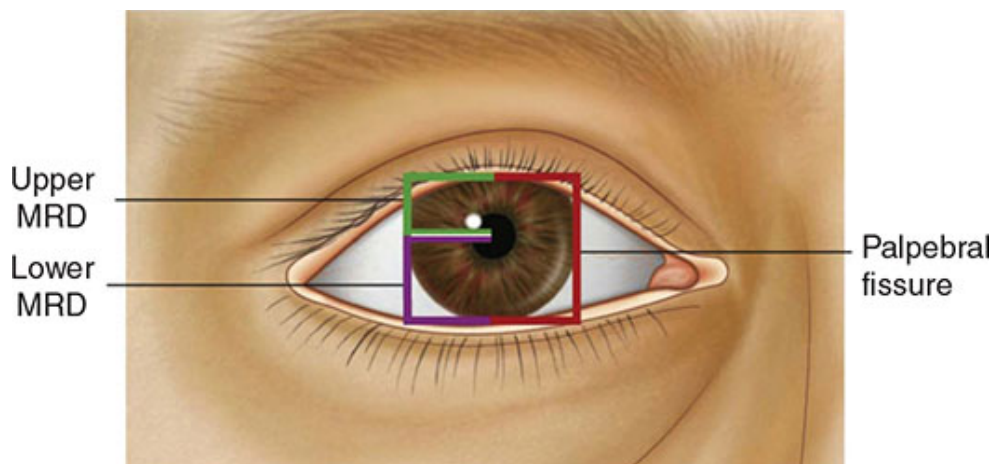


Figure 73-18. Ptosis is defined as a marginal reflex distance (MRD) less than 2 mm as measured from the pupil center to the upper lid margin. (Reproduced with permission from Robinson JK, Hanke CW, Siegel DM, et al: *Surgery of the Skin*, 3rd edition. Philadelphia: Elsevier, Inc; 2015).



Figure 73-19. Snap back testing of the lower eyelid.

Reviewing old photographs from the distant and more recent past is helpful to accurately tailor each surgery to a patient's individualized youthful facial features and bone structure. For example, if a patient had limited pretarsal show with low-set eyelid folds when they were younger, the surgical plan should still respect the patient's unique premorbid appearance.¹⁶ Prior to surgery, photographs without make-up and with hair pulled back are a prerequisite, and are also helpful in discussing preoperative planning with the patient.

Most insurance companies require clinical photographs and visual field images for preapproval purposes. The methods of obtaining precertification for insurance purposes continue to evolve as the world of health care changes.

An appropriate evaluation of the eyelids and face allows the surgeon to make many decisions regarding the surgical technique that might produce the best aesthetic outcome.

PREOPERATIVE PLANNING

Blepharoplasty is an elective procedure, and is performed on patients who are healthy or only have mild systemic disease. It may be performed using different anesthesia modalities, depending on patient and surgeon preference, as well as the length of planned surgery if additional aesthetic procedures are planned. In the cooperative patient, blepharoplasty can be performed under local anesthesia without sedation in a minor procedure room. Many patients and surgeons prefer to work in a dedicated operating room with IV sedation or general anesthesia.

The timing of surgery needs to be discussed with patients who are taking anticoagulant medications. Anticoagulant and antiplatelet medications should be stopped at least 2 weeks prior to surgery and held for 1 week postoperatively.^{26,36} If there are comorbidities that do not allow for the safe cessation of these medications, then the patient should consult with their cardiologist or hematologist to make other arrangements, such as using a short-acting anticoagulant to bridge the perioperative period (e.g., Lovenox). If this is not possible because of serious pre-existing medical conditions, blepharoplasty, a truly elective procedure, should be potentially avoided. There are other unique situations where blepharoplasty may be unwise, such as for monocular patients, those with body dysmorphic disorder, or those who have had multiple previous elective eyelid surgeries and maintain unrealistic goals for their appearance.

Ultimately, the surgeon's experience, the individual patient findings, and the particular expectations for surgery will dictate which approach is best for the aging eyelid.¹⁶ Surgical planning for upper lid blepharoplasty should be based on whether there is only excess skin or also associated brow ptosis, eyelid ptosis, steatoblepharon, and lacrimal gland prolapse. If there is concomitant brow ptosis, this should be addressed with a combined brow lift. If the patient does not want brow surgery, they should be made aware that the degree of brow ptosis could worsen after isolated blepharoplasty, creating the appearance of excess upper lid skin from the descended brow. They may feel that the surgeon performed an inadequate skin excision, when the real issue is that the ptosis of the lateral brow fat pad was not addressed. These patients tend to be dissatisfied with their postoperative result unless they are duly warned preoperatively. If there is associated eyelid ptosis, referral to an ophthalmologist should be pursued. Lacrimal gland prolapse can be addressed with resuspension.

The algorithm for lower lid blepharoplasty is more complicated.¹⁶ Fat pads that have prolapsed beyond the orbital rim should be addressed surgically with either debulking or repositioning, depending on the amount of fat present and volume loss at the lid–cheek junction. At times, there is minimal fat prolapse or excess skin, but prominent nasojugal and/or palpebromalar grooves, and volume augmentation with synthetic fillers or fat grafting alone may be sufficient.^{37,38} However, if there is concomitant orbital fat pad herniation that would remain after volume augmentation, lower lid blepharoplasty is recommended.

Patients with prominent globes and a negative vector are at higher risk for lower lid malposition following lower lid blepharoplasty. In this population, transconjunctival blepharoplasty is recommended with preservation of lower eyelid volume, possibly in conjunction with midfacial augmentation, and, if necessary, lateral canthal suspension.

If there is lower lid skin excess, it can be removed, either with a skin pinch subciliary approach, with laser resurfacing, or a combination of both. Ablative laser resurfacing may be used to improve lower lid rhytides in transconjunctival blepharoplasty. Because of the increased risk of pigmentary changes in more heavily pigmented skin types, ablative procedures are usually reserved for patients with Fitzpatrick skin type III or below. Skin condition may be electively optimized preoperatively with a 4- to 6-week course of topical nightly tretinoin (0.05–0.1%) and bleaching agents until approximately 2 weeks before treatment. Laser resurfacing is usually performed with a CO₂ or Er:YAG laser.³⁹ Both traditional or fractionated laser platforms can be effective, but fractionated laser treatments result in less erythema, edema, and faster healing times.⁴⁰

In the case of redundant or hypertrophic orbicularis muscle, a skin-muscle flap can be performed to resuspend the lower lid orbicularis and provide better support to the lid.⁴¹ Orbicularis thermoplasty can be performed using cautery to treat an overriding orbicularis.⁴² Among patients who have excess skin, herniated fat, and a prominent groove along the infraorbital rim, volume preservation transconjunctival blepharoplasty can be performed with fat repositioning. If there is still mild excess skin (<2–3 mm), ablative skin resurfacing can be used. If there is moderate remaining excess skin, a skin pinch excision can be performed in appropriate cases.⁴³

Lid laxity and tone should be evaluated in all patients. Most elderly individuals will have some degree of laxity. When there is a poor snap-back test or increased lid distraction, excessive skin excision should be avoided because of an increased risk of eyelid malposition. In cases of mild to moderate lid laxity, lid tightening with lateral canthopexy should be performed, especially when skin is being removed.⁴⁴ Canthopexy procedures do not shorten the lower lid. Instead, a lateral tarsal strip canthoplasty, which is a lid shortening procedure, should be reserved for severe cases of associated lid laxity and/or preoperative ectropion.^{45,46}

Approaches to the lower lid lengthening seen in the aging face²⁴ vary, but include effacement of the tear trough using fillers, fat transfer, release of the orbital retaining ligament, laser resurfacing, and midface lifting. Lower lid festoons, or malar mounds, can be addressed with ablative laser treatments, direct excision, skin-muscle flap blepharoplasty, midface lift, and orbitomalar ligament release.³³

TECHNIQUE

Many different surgical blepharoplasty techniques have been described in the literature. However, there is overall weak evidence-based support for most described approaches.⁴⁷ A basic limitation of oculofacial research is the variability in skill level of the surgeon for a range of different techniques. What matters most for patient and surgeon is that the postoperative functional and cosmetic outcomes match preoperative expectations. Good cosmetic outcome is highly dependent on the comfort level of the surgeon with a given surgical approach. Thus, what the surgeon knows and is most comfortable with might be more important than the actual choice of technique and surgical approach.

UPPER LID BLEPHAROPLASTY

Upper lid blepharoplasty with en bloc excision of upper lid skin, orbicularis oculi muscle, and/or orbital fat is the gold standard for the correction of dermatochalasis, and there are records of it being performed as far back as 2000 years ago.⁴⁸ There are variations described for the ideal skin marking

for upper lid blepharoplasty.^{49–51} One large retrospective series of over 400 patients aimed to determine the optimal blepharoplasty markings to avoid lateral skin excess, medial fullness, and an incision that is beyond the orbital rim.⁵² The group concluded that the medial extent of the incision should end 6 mm lateral to the angular vein, and the lateral extent should end 12 mm lateral to the interpalpebral fissure and extend superiorly at a 45-degree angle. Others support an arcuate or lenticular skin excision design.⁵³ For some, the most important aspect is a slight upward angle at both the medial and lateral ends of the wound to prevent webbing.¹⁵ Most advocate for leaving at least 1 cm of sub-brow skin or 20 mm of total remaining anterior lamella after skin excision according to Flower's rule.^{16,52} Regardless of which design is chosen, the “pinch” technique can also help guide the maximal allowable skin excision without induction of lagophthalmos.⁶

There is debate in the literature as to whether it is better to excise skin alone or skin and orbicularis muscle. Much of this controversy stems from the common complication of postoperative lagophthalmos. There are also varied opinions about different aesthetic outcomes if skin versus skin and muscle are removed. There are several well-designed, prospective studies addressing this question. While most of these studies are small (22 patients at the most), they all were designed in a split face fashion, were randomized, and used blinded graders for outcome assessment.

Kiang et al. sought to examine the degree of lagophthalmos in eyes that had skin only compared to skin and muscle excision. Over a 6-month follow-up period, lagophthalmos only occurred in eyelids that had more than 8 mm of orbicularis oculi muscle excised, suggesting that lesser amounts of muscle excision may not affect eyelid function.⁵⁴ Interestingly, the lagophthalmos resolved in most patients by 6 weeks postoperatively, suggesting that there may not be long-term sequelae even if larger amounts of muscle are removed. A similar conclusion was made in a small primate study where postoperative lagophthalmos was assessed based on the degree of orbicularis muscle excision. Lagophthalmos was only noted in monkeys that had all three segments of orbicularis removed (pretarsal, preseptal, and orbital), but not with smaller amounts excised.⁵⁵ Damasceno et al. found that there were significantly slower healing times and worse aesthetic ratings in the skin and muscle group compared to the skin only group during the early postoperative period. However, by 2 weeks after surgery, both groups were graded to be

the same.⁵ Conversely, others have found that there are no differences in aesthetic outcomes at any time point between eyelids with skin only versus skin and muscle excision.⁵⁶

Traditional upper lid blepharoplasty has centered on reductive principles, with the goal to excise variable amounts of skin, muscle and fat. Unlike lower blepharoplasty, less attention has been given to conservation and repositioning of upper lid volume. However, superior sulcus hollowing is a common postoperative complication,⁵⁷ prompting a recent shift toward volume preservation in upper lid blepharoplasty as well.^{50,58} There are many techniques described in the literature to address a sunken superior sulcus in upper lid blepharoplasty, including autologous fat grafting. The science of surgical microfat grafting is still lacking in robust evidence-based support, though several general principles have been recommended: (1) the donor site is unimportant in graft survival rates, (2) aspirated fat with large bore needles is better than excised fat for long-term survival, and (3) fat injection is best performed with a fine cannula with multiple passes at varying depths.⁵⁹ While supraperiosteal microautologous fat injection is well described for volume replacement in the upper lid, there are reports of success with fascia-fat composite grafting, dermis-fat grafting, and small aliquots of hyaluronic acid.^{37,60-63}

Nasal fat pad repositioning by creating a fat pedicle with central or lateral repositioning is also effective at preserving upper lid volume, and may also be a useful adjunct to blepharoplasty.^{9,64} Transconjunctival upper eyelid blepharoplasty has been described as a favorable approach in select patients who have a prominent nasal fat pad, but minimal or absent upper lid dermatochalasis.⁶⁵⁻⁶⁸ The main advantage of this technique is avoidance of an upper eyelid incision. It has also been effective in patients with isolated medial fat prolapse undergoing concurrent brow lift.^{69,70}

LOWER LID BLEPHAROPLASTY

There are two main approaches to lower lid blepharoplasty: transcutaneous and transconjunctival. The more traditional transcutaneous surgical approach requires a subciliary skin incision and trans-septal penetration to access the lower lid fat pads. The transconjunctival approach involves a

transconjunctival incision, with avoidance of the septum, to access the lower lid fat pads.

Transcutaneous lower lid blepharoplasty was first described in 1967.⁷¹ In experienced hands, it can be effectively used to address lower lid skin excess, ptotic orbicularis muscle, and herniated fat pads. There are many variations to the transcutaneous approach, including a skin-only flap, skin-muscle flap, and separate skin and muscle flaps, all with or without fat excision or fat redraping. There have been no retrospective or prospective studies comparing these approaches, and generally surgeon preference and experience guide clinical practice.

The main concern with the transcutaneous approach has traditionally been the feared complication of lower eyelid ectropion and retraction, which can occur in up to 30% of cases.⁷² Postblepharoplasty lower lid malposition is the most common complication from surgery, as well as the most common reason for reoperation.⁷³ The anatomic explanation for lower lid malposition after blepharoplasty has been violation of the orbital septum with subsequent scarring and cicatricial changes. However, a recent retrospective study showed no difference between rates of lower lid retraction for *transconjunctival* blepharoplasty performed with and without isolated violation of the orbital septum in over 500 patients, suggesting that eyelid malposition may be more related to “multilamellar” scar formation when tissue in addition to the septum is violated.⁷⁴ The location of the conjunctival incision in transconjunctival blepharoplasty may be a previously unrecognized factor in multilamellar scarring and ectropion development. The traditional location has been described as 1 to 2 mm below the inferior edge of tarsus. However, Undavia et al. recently advocated an incision 6.5 to 7.5 mm below the inferior tarsal border for the most direct access to the lower lid fat compartment and possible minimization of scarring.⁷⁵

While many have argued that lateral canthal support should be a requisite part of the lower lid blepharoplasty procedure to prevent ectropion and retraction,⁷⁶ others feel that lateral canthal support is *only* necessary when skin is being removed and/or aggressive laser resurfacing is being performed.^{77,78} Regardless, lid malposition seems to occur less frequently with concomitant canthal suspension.^{35,44,46,78–83} There are many different techniques described for obtaining lateral canthal support⁸⁴: lateral canthoplasty (canthal reattachment after cantholysis), lateral canthopexy

(canthal tightening without cantholysis), lateral tarsal strip, “mini-tarsal strip,” and lateral retinacular suspension. Lateral canthoplasty and canthopexy are generally reserved for those who need canthal support, but do not have lid laxity and do not need lid shortening.⁸⁵ The lateral tarsal strip procedure is reserved for those with excess lid laxity and results in lid shortening and tightening, but can be associated with longer healing time, a higher rate of dehiscence, and an unnatural contour to the lower lid.⁸⁶ The “mini tarsal strip” was developed to reduce postoperative morbidity associated with a full strip, but to still provide minimal lid shortening in cases of mild lid laxity and a similar tightening effect.⁸⁷ The lateral retinacular suspension provides superolateral elevation of the lateral canthal tendon through an upper blepharoplasty incision, but can lead to an unnatural appearing superotemporal web.⁴⁴

Attempts to reduce the rate of lower lid malposition popularized the transconjunctival approach,^{88–90} which was first described in 1924.⁹¹ This approach was further developed by Tessier for use in surgical exposure of the inferior orbital rim in craniofacial reconstruction and fracture repair.⁹² In addition to a reduction in the rate of postoperative eyelid malposition, the transconjunctival approach was felt to allow better exposure of the lower lid fat pads, the option of pedicled fat pad repositioning, and septal resuspension.^{93–96} Through the 1970s and 1980s, the predominant technique of cosmetic lower lid blepharoplasty evolved with the underlying principle of transconjunctival fat excision.^{97,98}

Since this approach eliminated an external skin incision, excess skin was addressed with a skin pinch, an ablative laser, or chemical peel.^{99–101} The skin pinch procedure has been extensively described as an adjunct to transconjunctival lower lid blepharoplasty in cases of excess skin. It can be combined with a lateral resuspension procedure with or without lower lid shortening.^{102,103} However, one retrospective study comparing transconjunctival lower lid blepharoplasty with and without skin pinch and no lateral canthal suspension, found no difference in postoperative rates of lower lid retraction, suggesting that a canthal resuspension may not always be necessary when a skin pinch is performed.⁷⁷

There are no direct comparative studies of transconjunctival and transcutaneous lower lid blepharoplasty. However, there is one retrospective

study comparing CO₂ laser-assisted transconjunctival lower lid blepharoplasty with laser skin resurfacing and CO₂-assisted transcutaneous lower lid blepharoplasty.¹⁰⁴ While it was a small study, there were similar success rates between treatment groups. CO₂ laser assistance can be used for both upper and lower lid transconjunctival and transcutaneous blepharoplasty. Compared to electrocautery, advantages include shorter operating time, less bleeding, and less tissue damage, with reduced postoperative discomfort.¹⁰⁵ Disadvantages include the potential for poor wound healing, time spent learning (median of 3 hours of hands-on training), and equipment expense. Safety measures include stainless steel eye protection for the patient and safety glasses for the operative team.¹⁰⁶ Some advocate for simultaneous CO₂ laser lower lid blepharoplasty with muscle and septal laser tightening.¹⁰⁷

While both transcutaneous and transconjunctival blepharoplasty with fat debulking may lead to satisfactory results, these approaches can worsen convexities at the tear trough and lid–cheek junction. As a result, there has been a recent trend toward greater preservation and augmentation of lower lid and midface volume. Part of this change in practice is related to a better anatomical understanding of the lid–cheek junction and midface.^{4,108–110} Instead of fat excision, many now advocate for fat preservation and repositioning as a more effective means of lower lid and midface rejuvenation. First introduced in isolation to address the tear trough deformity,^{111,112} fat repositioning was later described in combination with septal reset procedures and found to have relatively low complication rates with reproducibly successful cosmetic outcomes.^{113–115}

Since then, modified approaches of fat repositioning have additionally been described, mainly involving repositioning in the subperiosteal plane instead of only in the suprapariosteal plane.¹¹⁶ Subperiosteal repositioning is advantageous because it is relatively bloodless, offers a lower likelihood of injury to the infraorbital nerve because of better exposure, and allows for direct suturing of the fat pedicle to overlying periosteum.⁸⁹ However, more recent studies suggest that repositioning in the suprapariosteal plane is technically easier, with cosmetic outcomes that are just as good as subperiosteal repositioning.^{94,117}

When there is minimal herniation of orbital fat, but infraorbital hollowing, injectable filler treatment to augment volume loss without surgery has been effective for return of a more youthful contour.^{37,38,118} However, when there is herniation of orbital fat with a clear convexity along the length of the lower lid, fat excision and/or repositioning should be performed. Another component important to a smooth lid–cheek junction is the release of the orbicularis retaining ligament, which has been described with encouraging results.^{119,120} Midface lift can also be coupled with lower lid blepharoplasty to further support and elevate the lower lid.¹²¹

POSTOPERATIVE CARE

There are a range of postoperative regimens for upper and lower lid blepharoplasty, but very few evidence-based guidelines for postsurgical management. Cooling with ice packs is often advocated, though there is no clear evidence that cooling is helpful. Pool et al. performed a randomized study of 38 upper lid blepharoplasty patients for whom one eyelid was cooled postoperatively with ice packs and their other eyelid was untreated.¹²² They found significantly lower pain scores on day 1 in the cooled eyelid, but no differences between groups in terms of lid edema, erythema, or hematoma formation. While there was a difference in pain, overall pain scores were low, leading them to conclude that the recommendation of a postoperative cooling regimen could be abandoned. There is also evidence that inappropriate use of ice packs can lead to unintentional damage of delicate eyelid skin.¹²³

Other technologies have been explored to decrease postoperative pain, edema, and erythema. Pulsed electromagnetic energy has been studied in the context of wound healing, and may be beneficial for postoperative symptoms. Czyz et al. used ActiPatch, a device that emits low-level pulsed electromagnetic energy, on upper lid blepharoplasty patients.¹²⁴ While there were no objective differences in postoperative symptom grades, patients subjectively felt that the appearance of edema and ecchymoses was initially better on the ActiPatch side. However, the patch was not user friendly, difficult to apply, and resulted in a small skin burn in two patients at the adhesion site because of improper application.

Intensed pulse light (IPL) systems use flash lamps and computer controlled capacity banks to generate pulsed polychromatic high-intensity light across a range of different wavelengths. IPL has been used to treat facial hair, vascular lesions, pigmented lesions, acne, redness, and photoaging. In a recent prospective, randomized, double-blinded, controlled trial the effect of IPL on postoperative ecchymoses was examined.¹²⁵ Twenty eight patients were enrolled who had a variety of oculofacial procedures in which one side of their face was treated with IPL therapy postoperatively and the other side was treated with the normal postoperative regimen. In the early postoperative period, there was a significant reduction in the severity and color of ecchymoses on the IPL treated side, but the difference equalized after about 12 days postoperatively.

Hemostasis is a crucial part of eyelid surgery and postoperative wound healing. Apart from standard intraoperative use of cautery, which can be associated with tissue damage, there are few modalities available to alter the appearance of ecchymoses in the postoperative wound healing period. Kaolin is a mineral that has been effective in other areas of medicine at controlling hemorrhage when combined with gauze and applied to a surgical wound. Kondapalli et al. looked at kaolin embedded intraoperative gauze application to upper eyelid blepharoplasty wound beds and assessed the degree of postoperative inflammation and ecchymosis.¹²⁶ While there were no significant differences in intraoperative bleeding or postoperative edema, Kaolin application did result in a significant reduction in ecchymosis at postoperative days 4 and 7.

Arnica is a flowering herb that has been shown to reduce postsurgical edema and ecchymosis. While Seeley et al. found it to reduce the incidence of ecchymosis in facelift surgery,¹²⁷ its use in periorbital surgery has recently been explored with two well-designed, prospective, randomized, double-blinded studies.^{128,129} Both independent research teams found that there was no significant difference in postoperative pain, edema, or ecchymosis between arnica and nonarnica treated eyelids after upper lid blepharoplasty. A systematic review of the literature on the effectiveness of arnica in wound healing found similarly disappointing results with its use in other parts of the body.¹³⁰

COMPLICATIONS

Blepharoplasty, when performed correctly, is very safe and produces rewarding results. However, it can have devastating complications related to both vision loss and cosmetic deformity. Complications can be divided into two groups: (1) errors in preoperative measurements and (2) surgical errors.

When deciding how much skin to remove in upper lid blepharoplasty, a conservative approach is essential. The consequences of aggressive skin removal are more difficult to correct than the consequences of managing residual skin excess. Up to 5% to 10% of patients may need additional skin removal after blepharoplasty surgery.¹⁵ It is important to counsel patients that the need for additional skin removal should not adversely influence an overall successful cosmetic outcome. Residual skin excess usually results from underestimation of how much skin is present, and usually manifests with persistent temporal hooding. If there is residual dermatochalasis after blepharoplasty, the surgeon should always check the eyebrow position to ensure that there is not concomitant brow ptosis before consideration of further skin removal. If the surgeon does not agree with further skin removal despite a patient's wish for additional surgery, efforts should be made to explain proper lid function and the need for at least 20 mm of anterior lamella. Ultimately, one should wait at least 3 to 6 months before considering additional surgery.

Eyelid ptosis can occur after blepharoplasty as a result of unrecognized preoperative ptosis or due to inadvertent injury to the levator muscle during surgery. The upper eyelid height should always be checked preoperatively, and a preoperative discussion about expectations is essential to avoid postoperative disappointment. Early postoperative mechanical ptosis from surgical edema is not uncommon. However, if ptosis persists beyond the normal healing time, the levator muscle may have been traumatized during blepharoplasty surgery. For this reason, a strong knowledge of anatomy is necessary in blepharoplasty surgery to avoid injury to delicate eyelid structures.

As with all cosmetic procedures, patients expect postoperative symmetry. However, some patients will notice asymmetry postoperatively that was present preoperatively, which is why high-quality preoperative photos are essential. An asymmetric upper lid crease is an unfortunate complication that can be avoided with good preoperative measurements. The skin markings are

perhaps the most important step in achieving postoperative symmetry. Calipers should be used to obtain precise measurements. The natural lid crease should be used as the inferior border of the incision. If the lid crease is poorly defined or absent, standard guidelines for the Caucasian (7–8 mm for a man; 8–10 mm for a woman) and Asian eyelids (5–6 mm for a man; 6–7 mm for a woman) should be used.¹³¹ Slight early postoperative asymmetry may occur, but if this is persistent, surgical revision may be necessary. Overall, it is easier to raise a crease rather than to lower it.¹³² If a higher crease needs to be created, a new incision should be made at a higher location with crease reforming sutures to fixate underlying orbicularis to levator muscle. If a lower crease needs to be created, an incision should be made at the lower level with advancement of preaponeurotic fat or through the use of free fat pearls to prevent adhesion at the higher level.

One of the most common complications of lower lid blepharoplasty is retraction, causing frank ectropion or a rounded lateral canthal appearance (Fig. 73-20). This can be cosmetically disturbing and highly symptomatic from dry eye–related irritation. This kind of eyelid malposition often results from scarring of the middle lamella and/or aggressive skin removal, typically in the setting of unrecognized lower lid laxity. It is paramount to avoid excessive skin removal; usually only 2 mm of skin excision is required at the most.¹⁵ It is also important to explain to patients preoperatively that the goal of lower lid blepharoplasty is to improve lid contour, not to remove skin. Skin peeling or laser resurfacing should be used to address excessive lower lid skin, rather than direct skin excision. The treatment of lower lid retraction can be difficult, usually requiring surgical release of middle lamellar scarring and grafting with hard palate, fat, or acellular dermis.^{18,131–133} Skin grafting to the anterior lamella should be used as a last resort. Often, the final outcome of lower lid retraction repair is suboptimal.



Figure 73-20. Postblepharoplasty lower lid retraction.

Lagophthalmos, or inability to close the eyelids, can be a highly problematic complication after blepharoplasty (Fig. 73-13). Not only is it uncomfortable, but it can place the health of the cornea in jeopardy. Lagophthalmos can occur as a result of various causes, including excessive skin excision, excessive orbicularis oculi resection, postoperative orbicularis weakness, or lid retraction. Prior LASIK surgery, in particular, may place the cornea at risk even with very minimal lagophthalmos.¹³⁴ Early lagophthalmos from edema, decreased effort secondary to pain, or orbicularis oculi dysfunction is common and usually resolves with time. Artificial tears and ointments can be used to protect the ocular surface in the short-term. Usually 2 mm or more of lagophthalmos is symptomatic and, if persistent, may require surgical correction.

Inadvertent globe penetration during local anesthetic infiltration of the eyelid is a rare occurrence, but has been reported in the literature.^{135,136} This complication can be avoided using several techniques. While awake patients do not tolerate scleral shells well, a shell can be used in a patient having blepharoplasty surgery under general anesthesia to cover and protect the globe. Additionally, several modifications to injection technique can reduce

the risk of this occurring. The injection needle tip should always be directed away from the globe. Once the needle is engaged in the subcutaneous space, the lid should be lifted up off the globe for the duration of the injection. A small amount of anesthetic volume should be injected to create a fluid wave which will separate the subcutaneous tissues and create a pocket through which to continue advancing the injection needle.

Small amounts of hemorrhage are to be expected with any surgery, and often lead to postoperative bleeding. During the injection of local anesthetic, efforts should be made to avoid visible vessels. If a small hematoma begins to develop, pressure can be applied to the area intraoperatively to minimize postoperative ecchymoses. Patients should be counseled preoperatively regarding the risk of bruising so as to minimize postoperative concerns. If hemorrhage is diffuse, a preseptal hematoma can occur. This is usually associated with a tense, swollen, and ecchymotic lid. It is essential to check for retrobulbar hemorrhage in these situations. In contrast to a retrobulbar process, if the hemorrhage is isolated to the preseptal space, there is usually minimal or absent associated pain. Anterior hematomas are best managed conservatively with elevation of the head of the bed, ice, direct pressure compresses, rest, and close observation. Since evacuation of a preseptal hematoma can lead to recurrent bleeding, drainage is usually not necessary. This complication is very concerning to patients because it delays healing and is unsightly. However, it is important to reassure an affected patient that it rarely causes loss of vision and does not affect the final aesthetic outcome.

Retrobulbar, or postseptal, hemorrhage is one of the most feared complications of blepharoplasty surgery. Although it is rare, occurring at an incidence of 0.055%,¹⁵ it can lead to permanent vision loss. Retrobulbar hemorrhage usually occurs in the early postoperative period (within 24 hours of surgery), but vision loss from hemorrhage has been reported up to 9 days after surgery.¹³⁷ Minimizing strenuous postoperative activity for at least 10 days after surgery is recommended. Bleeding usually comes from an arterial source and can occur anteriorly with posterior extension through a septal opening or can start as a primary posterior process. The orbital cavity measures about 30 mL, and there is little room for expansion within this bony space. Blood collection within the orbit can cause compartment syndrome with symptoms of pain, proptosis, limitation of extraocular muscles, elevated intraocular pressure, an afferent pupillary defect from optic nerve compromise, and ultimate vision loss from retinal ischemia. While

permanent vision loss occurs only 0.045% of the time,¹³⁸ retrobulbar hemorrhage is an ophthalmic emergency. Diagnosis of a hemorrhage should be made on a clinical basis and time should not be wasted obtaining an imaging scan. The surgical wound should be explored and the culprit vessel cauterized. Immediate lateral canthotomy and inferior cantholysis of the lateral canthal tendon should be performed if an obvious bleeding source is not visualized or if a delay will not allow a return to the operative setting. Successful release of the lower lid is evidenced when the lateral lid can be placed flatly on the cheek. If the pressure continues to be elevated, the superior crus of the tendon can also be released.

Postoperative infection is rare since there is a robust vascular supply to the periorbital region. The most common infectious organisms are staphylococcus and streptococcus species.¹³⁹ However, methicillin-resistant *Staphylococcus aureus* and necrotizing fasciitis have been reported,^{141,142} as well as atypical mycobacteria.¹⁴⁰ Early diagnosis is critical to avoid rapid spread of infection and vision loss. There is a higher risk of infection in immunosuppressed patients. Symptoms of preseptal cellulitis usually include edema, erythema, and drainage from the wound. An atypical mycobacterial infection should be considered if there are multiple erythematous sites or in cases of significantly delayed wound healing. Preseptal infection can be treated as an outpatient with oral antibiotics and close follow-up. However, change in vision, limitation of extraocular motility, abnormal pupil responses, and proptosis can be signs of orbital cellulitis, which should be managed with inpatient admission, IV antibiotics and imaging. If an orbital abscess is present and there is no improvement in clinical examination after 24 to 48 hours of IV antibiotics, surgical drainage should be considered.

Diplopia occurring after blepharoplasty can be monocular or binocular. Monocular symptoms are present even when one eye is occluded, and causes include uncorrected refractive error, tear film disruption, corneal injury, or ointment use. Binocular symptoms disappear when one eye is occluded. After blepharoplasty, binocular diplopia can be either transient or permanent. Normal postoperative edema can cause transient binocular diplopia, which will resolve as the swelling subsides. Inadvertent extraocular muscle injection of local anesthetic can cause transient binocular diplopia.^{143,144} However, toxicity to the muscle belly can cause hypertrophy and fibrosis, leading to permanent muscle dysfunction. This is most commonly seen with

the inferior rectus muscle in lower lid blepharoplasty. If permanent binocular diplopia occurs, the patient should be referred to an ophthalmologist for further management. Another reason for persistent diplopia can be injury and subsequent scarring of the trochlea, the pulley of the superior oblique muscle, during over aggressive nasal fat pad excision.¹⁴⁵ Inadvertent injury to the inferior oblique muscle, which runs between the medial and central lower lid fat pads, can also occur. Finally, there can be inadvertent tethering of an extraocular muscle fascial sheath into a fat redraping suture or during septal resuspension.¹⁴⁶

There are about 100 intraoperative fires per year in the United States, and at least 15% of these result in serious injury.¹⁴⁷ Fires occur because of use of electrocautery, oxygen cannulas, and ethanol-based cleaning products. To decrease the risk of fire, the nasal cannula should be above the drapes to prevent oxygen trapping. If possible, oxygen should be turned off when cautery is being used. If it is not possible to discontinue oxygen, the FiO₂ should be reduced to less than 30%. Lashes and brow cilia should be moistened prior to cautery use.¹⁴⁸

Regardless of suture choice, wound dehiscence is possible. The risk of dehiscence is minimized with postoperative instructions to avoid heavy lifting, rigorous exercise, and placing the head below the waist. If dehiscence occurs, the wound edges should be freshened, de-epithelialized and, depending on the size of the opening, sutured closed. If the length of the dehiscence is less than 1 cm, the wound may be left to close by secondary intention with a good ultimate cosmetic outcome.¹⁵ Occasionally, focal inflammation occurs and results in a suture granuloma. This is more common medially and laterally where the suture knots are placed.¹⁵ Most suture granulomas resolve with time, although in refractory cases topical steroids or excision may be necessary.

STEP-BY-STEP GUIDE THROUGH UPPER AND LOWER LID BLEPHAROPLASTY

Upper Eyelid Blepharoplasty

The procedure can be tailored to the individual based on their gender and the location of their upper eyelid crease. In Asians, a discussion must occur preoperatively and special attention must be paid to the location of the crease. Most Asians will not wish to have Westernization of the eyelid crease, but may wish to have a double eyelid—a lid crease, which is placed much lower on the pretarsal eyelid.

Following intravenous sedation, Tetracaine drops (Alcon, Forth Worth, TX) are instilled into both eyes.

The eyelid crease is drawn in the operating room in the supine position with a fine-tipped marking pen, and symmetry is assessed using calipers (Viscot, Ultrafine, Alimed, Dedham, MA). An attempt is made to keep the eyelid crease in its original anatomic location, based on the patient's examination and on the location of the lid crease in youth (Fig. 73-21). In the absence of a clear eyelid crease, the lid crease can be marked centrally at 10 mm in women and 8 mm in men. If skin excess is apparent, the brows are retracted upward by the surgeon or assistant to facilitate accurate lid crease marking. Medially, in the vicinity of the punctum and canalicular eyelid, the proposed incision is drawn slightly higher than the natural lid crease to prevent web formation. Laterally, the crease is extended to a line drawn that intersects the ala nasi and the lateral canthus. Beyond this, the incision is drawn in a slightly upward direction following a natural smile line no further than the lateral orbital rim.



Figure 73-21. The eyelid crease.

If a brow lift is not being performed, the upper limits of skin excision are also drawn. Using a forceps and a pinch technique, skin of the upper eyelid is grasped gently and pulled upward as the proposed area of maximum skin excess is drawn in a downwards direction. Any eversion of the upper eyelid indicates that too much skin is being excised, and less skin should be placed within the confines of the markings. This procedure is performed across the entire eyelid. Slightly more aggressive excision laterally can be accomplished. Nasally, over-excision can result in abnormalities of eyelid closure and web formation.

In patients with severe dermatochalasis, and in whom the brow skin could be sewn to the lid crease because of the degree of skin excess, the surgeon should be conservative and leave *at least* 1 cm of infrabrow non-hair-bearing skin unresected on the upper eyelid (Fig. 73-22). Brow lift should be considered concomitantly, or the patient should be made aware that they will continue to have the appearance of skin excess due to brow ptosis.



Figure 73-22. In patients with severe dermatochalasis, and in whom the brow skin could be sewn to the lid crease because of the degree of skin excess, the surgeon should be conservative and leave at least 1 cm of infrabrow non-hair-bearing skin unresected on the upper eyelid.

If a brow lift is to be performed, the pinch test is omitted. Once the brow position has been set by the brow lift using a fixation technique, the amount of skin excess can be judged by gently draping the redundant skin over the eyelid crease incision with the eye closed.

Once appropriate markings have been made, the upper eyelids are infiltrated with a mixture of lidocaine 1% with 100,000 epinephrine mixed with Marcaine 0.5% with 1:200,000 epinephrine. Hyaluronidase can be added in a 9:1 mixture and aids in diffusion of the anesthetic (Fig. 73-23).



Figure 73-23. The upper eyelids are infiltrated.

A satisfactory period of time is allowed to elapse for epinephrine effect and analgesia. The patient is then prepped and draped in the usual sterile manner.

Using a #15 blade, a CO₂ laser, or a Colorado needle on pure cut mode, a lid crease incision is made (Fig. 73-24), deepened through orbicularis muscle, and the skin muscle flap is raised exposing the orbital septum (Fig. 73-25). This approach allows the surgeon to modify the amount of skin removed after fat reduction or mobilization to assure an aesthetic result.



Figure 73-24. A lid crease incision is made.



Figure 73-25. The skin muscle flap is raised, exposing the orbital septum.

The orbital septum is now opened centrally and across the eyelid. The central fat pad above the levator aponeurosis is immediately visualized ([Fig. 73-26](#)). The surgeon should strive to stay relatively superior so as to avoid

inadvertent injury to the levator aponeurosis. The fat effectively protects the levator aponeurosis and serves as a landmark that can prevent injury to the aponeurosis. The septum is opened after buttonholing medially and in a slightly superior direction under the orbicularis muscle.

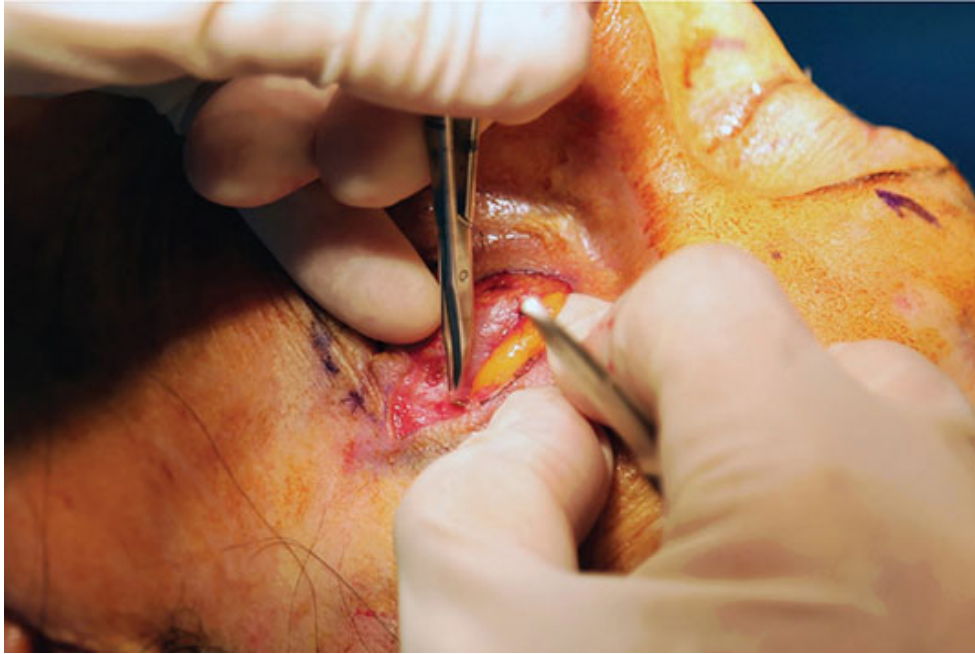


Figure 73-26. The orbital septum is opened centrally and across the eyelid so that the central fat pad above the levator aponeurosis can be visualized.

A gentle spreading technique is employed using an iris scissors to expose the nasal fat pad ([Fig. 73-27](#)).

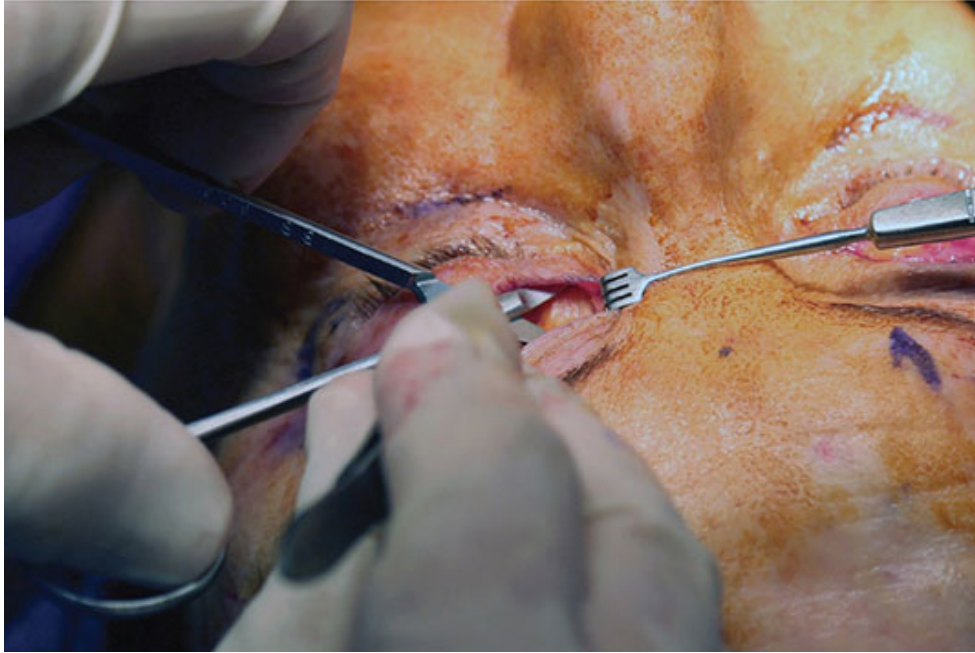


Figure 73-27. A gentle spreading technique is employed using an iris scissors to expose the nasal fat pad.

The nasal fat pad is injected with local anesthetic (Fig. 73-28). The fat pad can be clamped (Fig. 73-29), cauterized (Fig. 73-30) and removed, repositioned using absorbable suture, or partially debulked and sutured to any concavities that exist in the upper sulcus.



Figure 73-28. The nasal fat pad is injected with local anesthetic.



Figure 73-29. The nasal fat pad can be clamped.

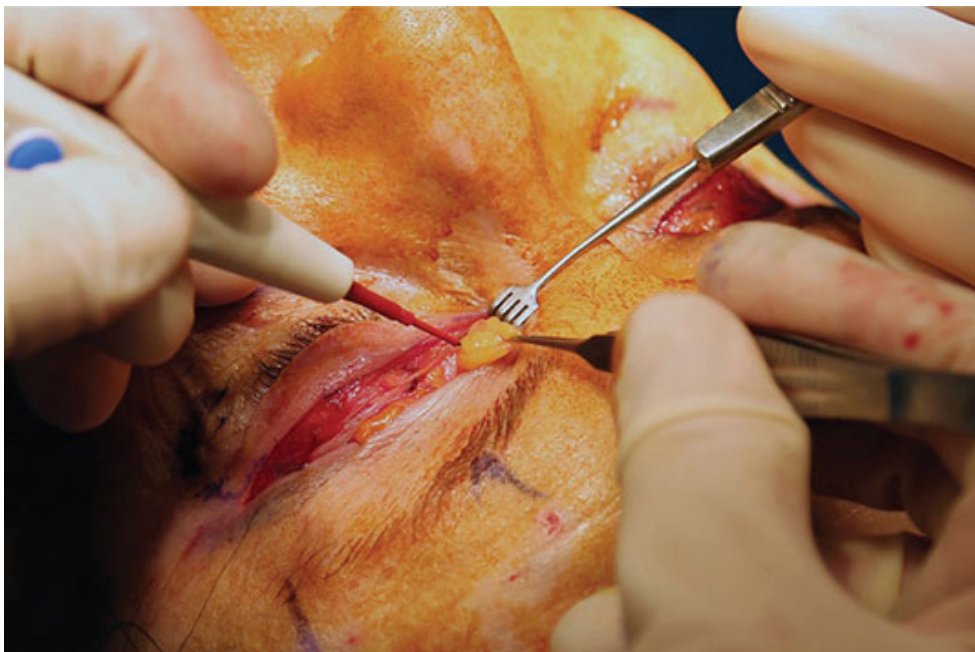


Figure 73-30. The nasal fat pad can be cauterized.

The central fat pad is minimally trimmed, if ever. This is accomplished with a scissors, and monopolar or bipolar cautery may be used to control bleeding. Lacrimal gland prolapse, if present, is treated using a 6-0 Vicryl horizontal mattress suture, securing the orbital lobe of the lacrimal gland within the lacrimal gland fossa.

The skin and/or muscle is now gently redraped over the upper eyelid. All redundant skin can be excised (Fig. 73-31). The eyelid must remain closed and the amount of skin excess can be tailored to allow for the removal of skin or skin muscle, allowing the eyelid to close completely, assuring that it will close postoperatively.



Figure 73-31. The skin and/or muscle is gently redraped over the upper eyelid and all redundant skin can be excised.

Hemostasis is verified with the monopolar cautery. The analogous procedure is performed on the contralateral side. All preoperative assymetries are noted and fat debulking is titrated according to the preoperative evaluation as well as to what becomes apparent at the time of surgery.

The excised upper eyelid skin that is excised along with the fat may be photographed, so as to have a record of what was removed at the time of surgery. This maintains an operative record, helps the surgeon gain

experience especially when viewing the postoperative result, and allows the patient to become aware of the typically minimal amount of tissue that is removed to achieve an aesthetic result.

The skin is now reapproximated, attaching the pretarsal skin edge directly to the levator aponeurosis in three locations using a 6-0 absorbable Vicryl suture (Fig. 73-32). The remaining skin is closed with a 6-0 Prolene suture either in running fashion or in subcuticular fashion.



Figure 73-32. The skin is reapproximated, attaching the pretarsal skin edge directly to the levator aponeurosis in three locations using a 6-0 absorbable Vicryl suture.

Ointment is placed in the eyes and on the incisions. The drapes are removed. If planned, lower eyelid surgery can now be accomplished.

Lower eyelid blepharoplasty

The vast majority of lower lid blepharoplasty procedures are accomplished using a transconjunctival approach with canthal tightening, lower lid canthal suspension, structural fat transfer to the tear troughs, midcheek, SOOF and cheeks, and periorbital laser resurfacing. In patients with Fitzpatrick Class I-III skin, laser resurfacing is accomplished simultaneously. In patients whose skin is Class IV or above, a skin pinch excision in the presence of skin

redundancy may be performed. In cases where orbicularis muscle is redundant or hypertrophic, orbicularis thermoplasty or postoperative botulinum toxin may be utilized.

Canthal tightening is performed in the majority of patients, as after laser resurfacing many patients are predisposed to developing ectropion. It is done as a preventive measure and aids in assuring good lid position in the postoperative period.

In the operating room, preoperative photographs of the patient in an upright position may be reviewed to estimate the amount of fat excess. This fat excess disappears in the supine position, particularly the temporal fat pad. It is also helpful to reference photographs of the patient at a younger age, to aid in restorative aspects of the brow, cheek, and midface.

Following intravenous sedation, the lower eyelids, lateral canthi, tear trough, and cheeks are infiltrated with a mixture of 1% Lidocaine with 100,000 epinephrine mixed with Marcaine 0.5% with 1:200,000 epinephrine (Fig. 73-33). Hyaluronidase is added, approximately 250 units per 1 cc in a 9:1 mixture.



Figure 73-33. Before beginning lower lid blepharoplasty, the lower eyelids, lateral canthi, tear trough, and cheeks are infiltrated with local anesthetic.

An adequate period of time is allowed to elapse. The patient is prepped and draped in the usual sterile manner.

A corneoscleral shield is placed in the eye (Fig. 73-34). A lateral canthal incision is made 2 mm from the lateral canthus in a natural rhytid at least 5 mm from the upper eyelid incision if a concomitant upper blepharoplasty was performed. This incision measures 6 to 7 mm in length and is made through both skin and orbicularis either with a Colorado needle, a #15 blade, or a CO₂ laser (Fig. 73-35). Using the pinch test (Fig. 73-36), a small amount of lower lid skin is excised (Fig. 73-37).



Figure 73-34. A corneoscleral shield is placed in the eye.



Figure 73-35. A lateral canthal incision measures 6 to 7 mm in length and is made through both skin and orbicularis either with a Colorado needle, a #15 blade, or a CO₂ laser.



Figure 73-36. Using the pinch test for excision.

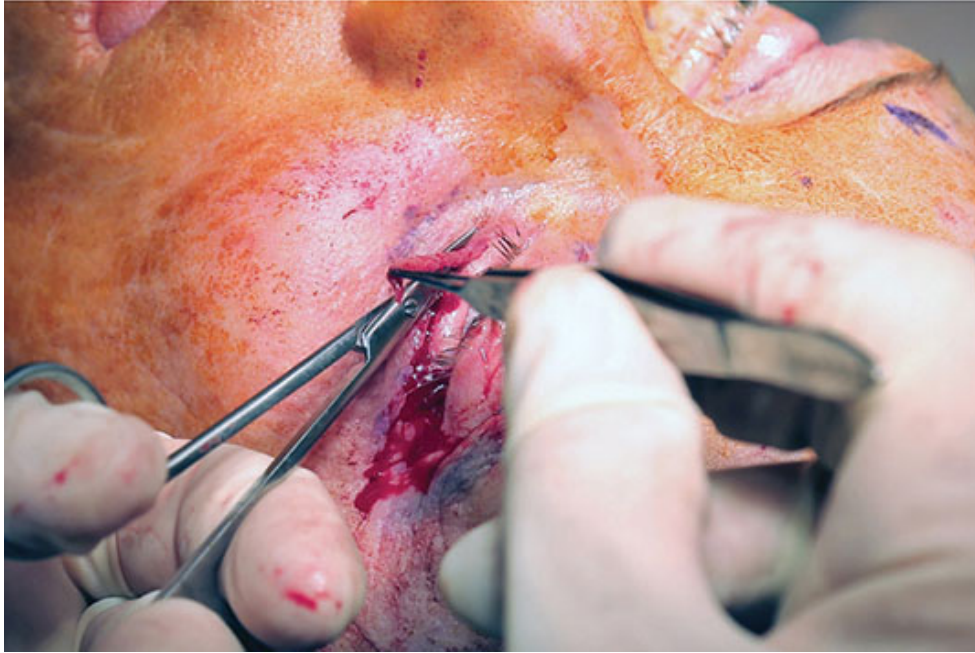


Figure 73-37. A small amount of lower lid skin is excised.

The assistant now grasps the tarsal edge on the conjunctival side using two Knapp rake retractors ([Fig. 73-38](#)).

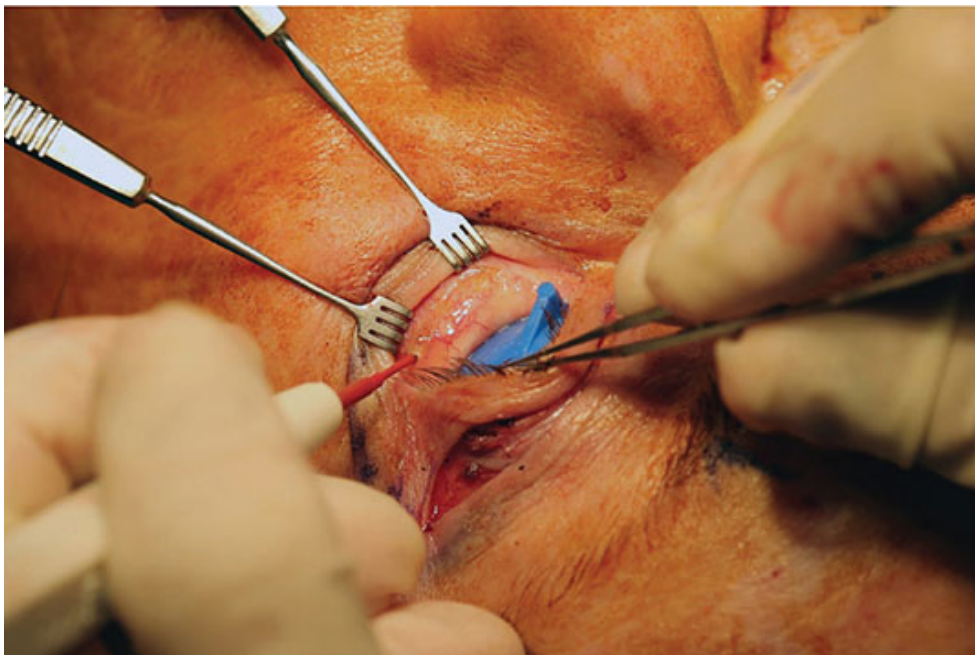


Figure 73-38. The assistant grasps the tarsal edge on the conjunctival side using two Knapp rake retractors.

An incision is made 5 mm below the inferior tarsal border as the globe is balloted forward, exposing the conjunctiva and lower eyelid retractors from approximately 2 mm medial to the caruncle to the lateral canthus (Fig. 73-39).



Figure 73-39. An incision is made 5 mm below the inferior tarsal border as the globe is balloted forward, exposing the conjunctiva and lower eyelid retractors from approximately 2 mm medial to the caruncle to the lateral canthus.

The lower eyelid retractors are now grasped firmly, and using a cutting cautery or a CO₂ laser or gentle blunt spreading technique with an iris forcep, the orbicularis muscle is dissected from the orbital septum down to the arcus marginalis to the orbital rim. Once in the correct plane, a cotton tip applicator is used to gently dissect the orbicularis from the septum (Fig. 73-40).

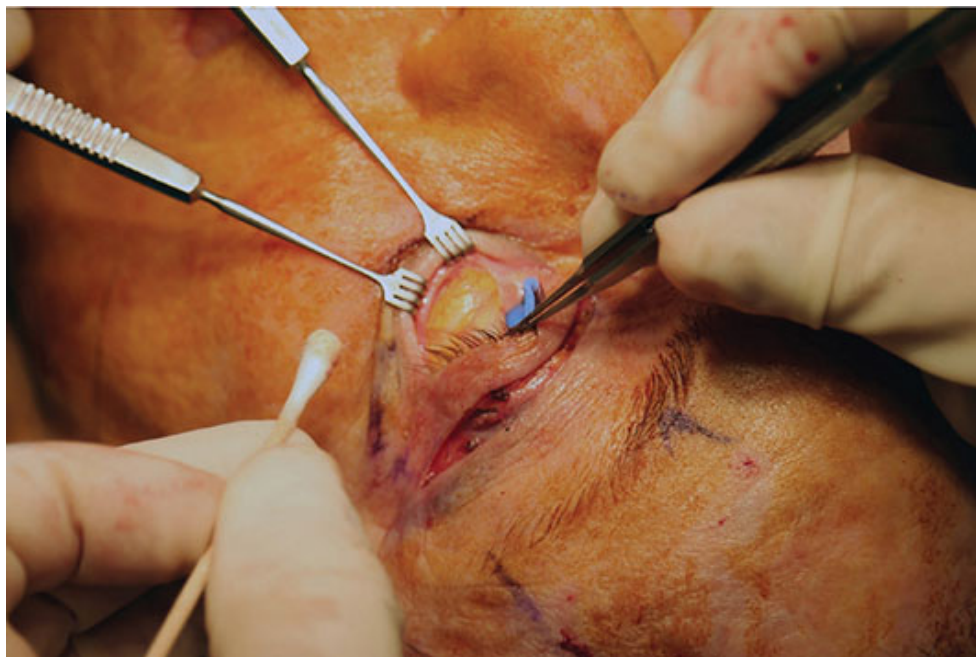


Figure 73-40. A cotton tip applicator is used to gently dissect the orbicularis from the septum.

A 4-0 Silk suture is placed in the lower eyelid retractor's conjunctiva complex over the globe and a hemostat is used to clamp it to the drape (Fig. 73-41). This produces greater exposure of the inferior fat pads.



Figure 73-41. A 4-0 silk suture is placed in the lower eyelid retractor's conjunctiva complex over the globe and a hemostat is used to clamp it to the drape.

The orbital septum is opened across the entire lower eyelid, exposing the central fat pad, the nasal fat pad, and the temporal fat pad (Fig. 73-42). When necessary, the lateral retinaculum is divided, as there are two fat pads in the temporal aspect of the lower eyelid which become exposed. Using a gentle spreading technique with an iris scissor, the nasal, central, and temporal fat pads are further exposed. The fat compartments are injected with local anesthesia, clamped (Fig. 73-43), cauterized, or removed under direct visualization (Fig. 73-44). While many surgeons prefer this technique to structural fat transfer, repositioning fat below the orbital rim may result in lumps, edema and, rarely, ectropion of the eyelid. The fat is removed and partially, but not completely debulked (Fig. 73-45). The art of this technique involves what is left behind rather than what is removed.

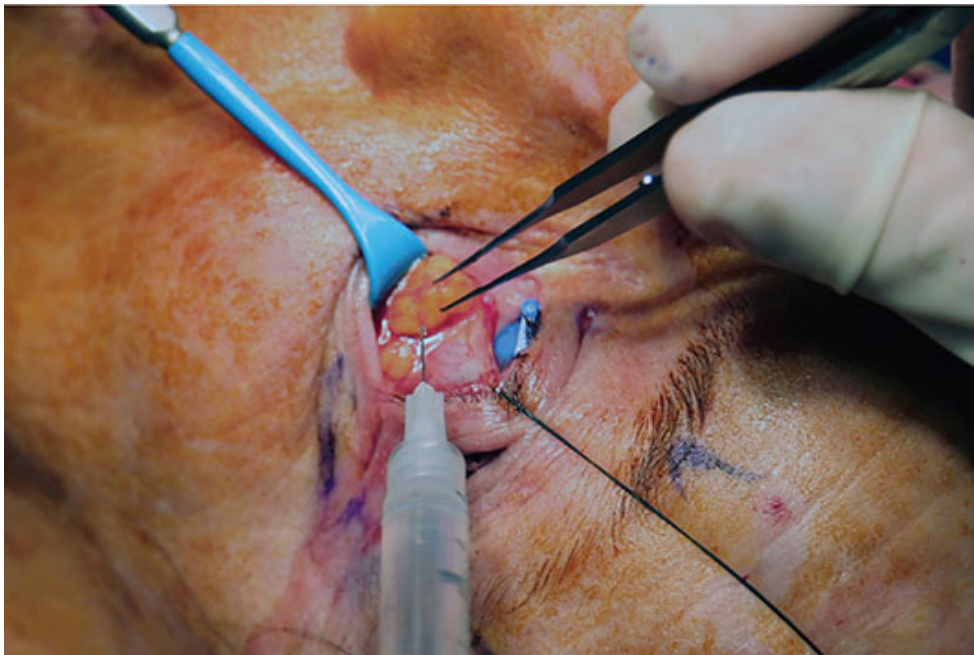


Figure 73-42. The orbital septum is opened across the entire lower eyelid, exposing the central fat pad, the nasal fat pad, and the temporal fat pad.



Figure 73-43. Using a gentle spreading technique with an iris scissor, the nasal, central, and temporal fat pads are further exposed. The fat compartments are injected with local anesthetic and clamped.



Figure 73-44. The fat compartments are injected with local anesthesia, cauterized or removed under direct visualization.



Figure 73-45. The fat is removed and partially, but not completely, debulked.

The fat is clamped, cauterized, removed, or directly cut using a blend mixture with monopolar cautery. Hemostasis must be meticulous, and any bleeding should be controlled. The fat pads are surrounded by a capsule, which is vascular, but the fat itself is relatively avascular, and bleeding should be minimal if the fat pads alone are resected.

A typical endpoint would involve slight visualization of the inferior orbital rim. Blotting the fat gently should allow the fat to come forward, level with the orbital rim. The temporal fat pad is slightly more aggressively debulked. The nasal fat pad is usually minimally excised.

Careful hemostasis is maintained. At this time, the 4-0 silk suture is removed. The scleral shell is removed and the eyelid is gently repositioned, verifying that there are no adhesions between the cut edges of the conjunctiva. Ectropion can occur if the eyelid is not gently repositioned in its normal anatomic position.

The analogous procedure is performed on the contralateral eye. Usually the amount of fat resected corresponds to any asymmetries—if slightly more fat is observed on one side than the other preoperatively, slightly more fat is resected.

At this time, a 4-0 Vicryl suture is used in a horizontal mattress suture to perform a lateral canthopexy (Fig. 73-46). The suture is passed from the

inferior tarsal border and attached directly to the arcus marginalis. This is performed in horizontal mattress fashion. Both edges of the Vicryl suture are passed posteriorly within the orbital periosteum, aiming to reinforce the attachments of the lateral canthal tendon at Whitnall's tubercle. The procedure is performed bilaterally and, prior to cinching the sutures, symmetry is verified.

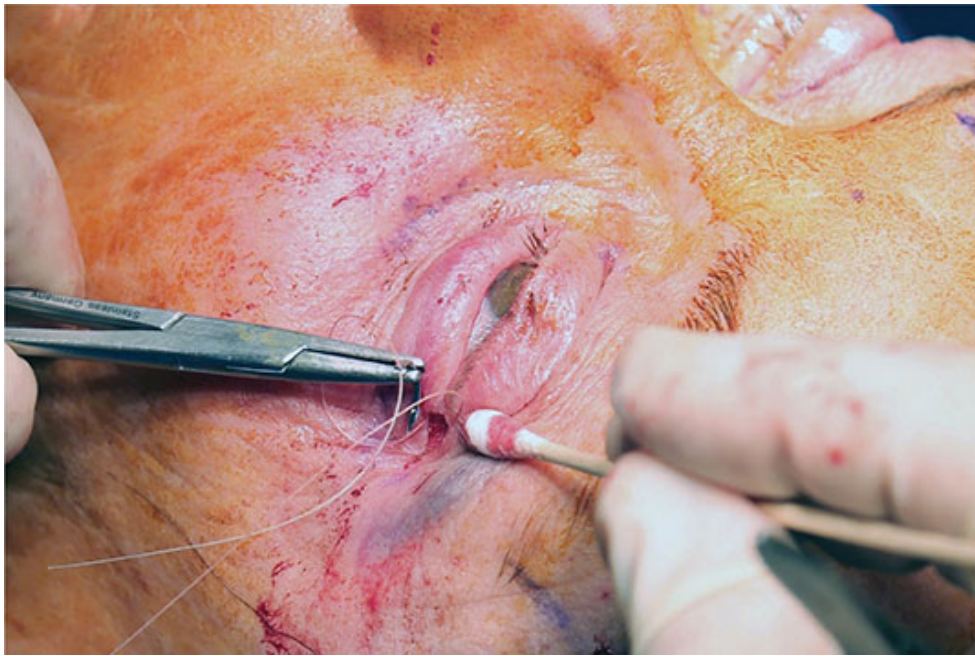


Figure 73-46. A lateral canthopexy is performed by placing a horizontal mattress suture with a 4-0 Vicryl suture.

At this time the orbicularis is closed with a single 6-0 chromic suture and the skin is closed with multiple 6-0 fast-absorbing gut sutures.

When necessary, if chemosis supervenes from the transconjunctival approach, a 4-0 silk suture is passed as a Frost suture, which remains in place for 24 to 48 hours (Fig. 73-47).



Figure 73-47. If chemosis supervenes from the transconjunctival approach, a 4-0 silk suture is passed as a Frost suture, which remains in place for 24 to 48 hours.

In the course of surgery, fat transfer may be performed as well (see [Chapter 61](#)).^{149,150}

Laser resurfacing is performed after the disposable drapes have been removed. Either fully ablative or fractional laser therapy can be used. A metal corneoscleral shield is placed in the eyes and appropriate laser precautions are taken using wet facial drapes. The lower eyelid is resurfaced using two passes. The second pass concentrates at the tear trough. If festoons are present, these are also treated aggressively with a fully ablative laser. The pretarsal lower eyelid is generally treated a single time to avoid ectropion.

The metal shields are now removed from the eyes and the areas are treated with topical Aquaphor or an occlusive dressing (Flexzan). Antibiotic ointment or antibiotic sterile ointment is instilled into the eyes.

Postoperatively, patients are treated with cool compresses.

CAUTIONS

Brow Lift

Be wary of the patient that wants only eyelid surgery, but also needs a brow lift. These patients may have the appearance of excess eyelid skin, but they also have brow descent and usually have less dermatochalasis when the brow is manually lifted during the preoperative evaluation. Brow ptosis after blepharoplasty occurs from unrecognized preoperative brow ptosis, but can also develop from excess skin removal. If skin is removed in the setting of brow ptosis, the brow is often pulled further downwards postoperatively. Again, 20 mm of anterior lamella should always be left remaining after blepharoplasty. If both a brow lift and blepharoplasty are planned, the order of procedures is important. An upper lid skin crease incision should be made, followed by the brow lift. The remaining degree of excess upper lid skin should then be examined, and a tailored skin excision can subsequently be performed. Worsening of brow ptosis after upper lid blepharoplasty is a difficult problem to fix and may require skin grafting.

Aggressive Fat Removal

Superior sulcus deformity or hollowing of the upper sulcus can occur following blepharoplasty if too much fat is removed. With age, the central fat pad atrophies, while the medial fat pad becomes more prominent. Recent awareness about the importance of fat preservation in the upper lid has led to a reduction in fat excision, especially centrally and laterally. Overaggressive resection may lead to hollowing of the superior sulcus, which produces an aged appearance. The location and extent of fat excess should be carefully documented preoperatively, and minimal fat excision and/or repositioning should be performed intraoperatively.¹⁵¹

Volume Replacement and Cautions

Volume replacement to the upper or lower lid can be achieved using a range of different approaches. Minimally invasive techniques include autologous fat or three-dimensional fillers. Hyaluronic acid–based fillers have become increasingly popular and are now the gold standard of dermal fillers because of their efficacy and safety. Unlike other types of fillers, their effects may be reversed through the use of hyaluronidase. Hyaluronidase is a hyaluronic acid degrading enzyme that comes in an animal and human recombinant form.

It is used to correct the side effects of hyaluronic acid–based fillers, including (1) over correction or superficial implantation of hyaluronic acid, (2) inflammatory or noninflammatory nodules, and (3) local or remote vascular occlusion.¹⁵² Any surgeon using hyaluronic acid–based fillers should have hyaluronidase available if needed, as well as an understanding of appropriate injection technique.

The most feared complication of filler injection is permanent vision loss from intravascular occlusion. In cases of possible embolism and vision loss, the filler must be reversed within 90 minutes to avoid permanent blindness.¹⁵³ A strong understanding of periorbital vascular anatomy is necessary when performing filler injection to avoid inadvertent vascular cannulation. Additionally, during deeper injections where vessels with larger diameters are located, appropriate technique with aspiration before injection is essential to avoid intravascular injection, though even meticulous technique does not guarantee appropriate placement. Since the central retinal artery is an end artery, there are no vessels that can assist in reperfusion in the setting of a central retinal artery occlusion. Permanent vision loss is inevitable if a filler thrombus is not reversed. Most argue for either periorbital or retrobulbar hyaluronidase injection when confronted with this situation.^{153–158} Interestingly, hyaluronidase does not have to be injected directly into the occluded vessel. Even when injected adjacent to an affected vessel, it has been shown to dissolve intravascular hyaluronic acid.¹⁵⁵

Webbing

Medial or lateral canthal webbing can occur in upper lid blepharoplasty depending on the placement of the lid incisions. Medially, a web can develop if the wound extends too close to the lid margin, is not angled sufficiently upward, or is too far medial. An additional technique to avoiding a medial web is to leave the medial 4 mm of the upper lid incision unsutured. This wound is small enough to avoid wound gaping, but can avoid an unnatural fold at the medial portion of the wound. Laterally, a web can occur if too much skin is removed or if there is not an adequate upward angle to the shape of the incision beyond the lateral canthus. This complication is more common in Asians (who have a naturally lower lid crease), non-Asian individuals

who have a low lid crease, and people who have concomitant brow ptosis. Again, proper markings are essential to successful postoperative outcomes.

Conjunctival Chemosis

Conjunctival chemosis, or swelling of the conjunctiva, following blepharoplasty, especially lower lid blepharoplasty, can sometimes occur with varying degrees of severity (Fig. 73-48). It is estimated to occur in about 1% of lower lid blepharoplasty cases.¹⁵⁹ There are small case series and anecdotal experiences described in the literature, but very few larger retrospective series.¹⁶⁰ Although the mechanism is not entirely certain, chemosis likely develops as a result of indirect surgical trauma and/or interruption of lymphatic drainage pathways. It seems to occur more commonly in blepharoplasty cases where a lateral canthopexy or canthoplasty is performed.¹⁶⁰ Patients with pre-existing conjunctivochalasis, or conjunctival laxity, may be predisposed to developing postoperative chemosis.¹⁶¹ Mild chemosis may initiate a cycle that causes poor tear film coverage of the ocular surface, worsening conjunctival dessication, chemosis, worsening distraction of the lid from the globe, and further exacerbation of chemosis.



Figure 73-48. Mild postsurgical conjunctival chemosis.

There are several interventions that can be performed to break this cycle. For postoperative chemosis, topical phenylephrine drops (2.5%), topical steroid drops or ointment and lubrication can lead to resolution. If chemosis is persistent, a 24-hour pressure patch can be used. If chemosis continues to be refractory, a temporary suture tarsorrhaphy may be necessary. If there does not seem to be any associated conjunctival inflammation, needle incision of the conjunctiva can be performed with or without excision or gentle cauterization of excess conjunctiva and Tenon's capsule. Conjunctival incisions can also be performed to allow drainage of fluid. If chemosis is persistent due to poor eyelid apposition with the globe, blepharoplasty revision surgery may be necessary.^{162,163}

Ectropion

Lower lid ectropion after blepharoplasty is a troublesome postoperative complication. It has traditionally been associated with the subciliary approach, but can also occur with a tranconjunctival incision and in cases of aggressive laser resurfacing. While its development is primarily related to unaddressed preexisting lid laxity, scarring of the middle lamella, and overzealous skin excision, there are more subtle preoperative clinical findings that may also be contributory. These include reduced orbicularis function, negative vector eyelid topography (as evidenced by the cornea extending beyond the border of the midface on sagittal head position), and volume deficiency of the inferior eyelid and/or orbit.¹⁶⁴ A detailed preoperative assessment that includes these oculofacial features may help guide the surgeon toward creating additional lateral canthal support during blepharoplasty surgery. These patients should also be counseled regarding their higher risk of postoperative eyelid malposition.

While it continues to be difficult to reliably predict which patients will develop lower lid ectropion, the management of postblepharoplasty lower lid retraction and ectropion may be an even more challenging task. While treatment of severe cases usually involves posterior lamellar grafting, controversy exists regarding optimal surgical correction of lower lid retraction and long-term outcomes for each procedure. The transeyelid midface lift has been described in the context of lower lid retraction repair after blepharoplasty. It can be performed through a transcutaneous or

transconjunctival approach. This technique takes advantage of the superficial musculoaponeurotic system (SMAS) to mobilize and anchor the midface superiorly through release of the orbicularis retaining and the zygomaticocutaneous ligaments. While this procedure alone can be effective in elevating the midface in mild cases of gravitational descent and volume loss, in moderate to severe postblepharoplasty lower lid retraction, it is more effective and long-lasting when combined with posterior lamellar grafting.¹⁶⁵ Graft materials may include hard palate, ear cartilage, or nonautologous substitutes, such as xenografts, cadaveric dermis, or dura.^{166,167} Nonautologous graft materials can be covered with conjunctiva which may reduce the incidence of graft resorption.¹⁶⁶ In rare instances, skin grafting may need to be employed to restore anterior lamellar vertical length. Techniques have been described to minimize complications associated with skin grafting.^{132,168,169}

For mild cases of lower lid retraction and massage, there is anecdotal support of digital massage in the early postoperative period.¹⁷⁰ While not specifically described for postblepharoplasty ectropion, lid injection of antimetabolites such as 5-fluorouracil (5-FU) and corticosteroids have been used to successfully treat thyroid eye disease-related lid retraction and cicatricial ectropion from anterior lamellar skin grafting.^{168,171} While injectable 5-FU can reduce cicatricial changes that lead to ectropion, topical and systemic 5-FU have been associated with the *induction* of lower lid ectropion as well.¹⁷²⁻⁻¹⁷⁴ Injection of hyaluronic acid filler has also been successfully used to treat lower lid retraction.¹⁷⁵



A



B

Case 1. A 65-year-old woman (A) preoperatively and (B) 7 months after bilateral upper and lower lid blepharoplasty, lower lid laser resurfacing with Sciton dual erbium laser, autologous structural fat transfer (0.8 cc/tear trough, 1 cc to SOOF, 1-cc lateral cheeks), and lateral canthal tightening.



A



B

Case 2. A 60-year-old woman (A) preoperatively and (B) 11 months after bilateral upper and lower lid blepharoplasty, periocular microneedling, full face laser with Sciton dual erbium laser, autologous

structural fat transfer (0.8 cc/tear trough, 1 cc to SOOF, 1-cc lateral cheeks), facelift, submentoplasty, and neck liposuction.

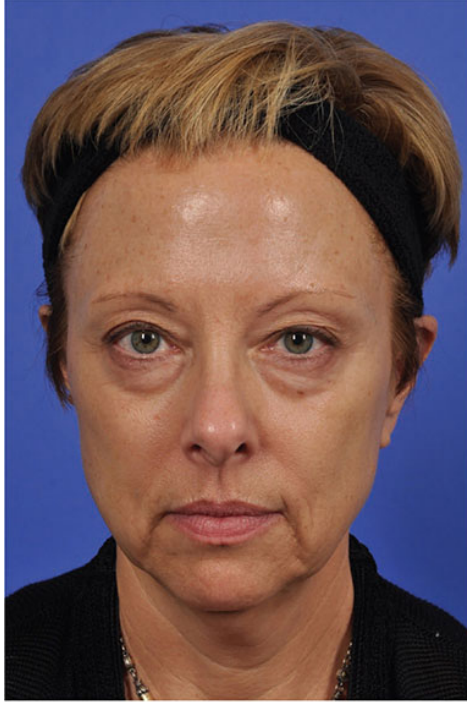


A



B

Case 3. A 73-year-old man (A) preoperatively and (B) 6 months after endoscopic bilateral brow lift and upper lid blepharoplasty.



A



B

Case 4. A 55-year-old woman (A) preoperatively and (B) 7 months after bilateral upper and lower lid blepharoplasty, autologous structural fat transfer (0.8 cc/tear trough, 1 cc to SOOF, 1-cc lateral cheeks), and lateral canthal tightening.



A



B

Case 5. A 54-year-old woman (A) preoperatively and (B) 7 months after bilateral endoscopic brow lift, midface lift, upper and lower lid blepharoplasty, full face laser with Sciton dual erbium laser, lateral canthal tightening, face lift, and submentoplasty.



A



B

Case 6. A 66-year-old woman (A) preoperatively and (B) 1 month after bilateral upper and lower lid blepharoplasty, lateral canthal tightening, autologous structural fat transfer (0.8 cc/tear trough, 1 cc to SOOF, 1-cc lateral cheeks), and endoscopic brow lift.

CONCLUSIONS

Blepharoplasty is a very common procedure, and has the potential to have a major impact on patients' quality of life. Perhaps even more than with other surgical approaches, preoperative evaluation and careful measurements and markings are of paramount importance in order to maximize the chance of a pleasing aesthetic outcome and minimize the risk of complications, and a thorough appreciation of periorbital anatomy is an absolute prerequisite to blepharoplasty.

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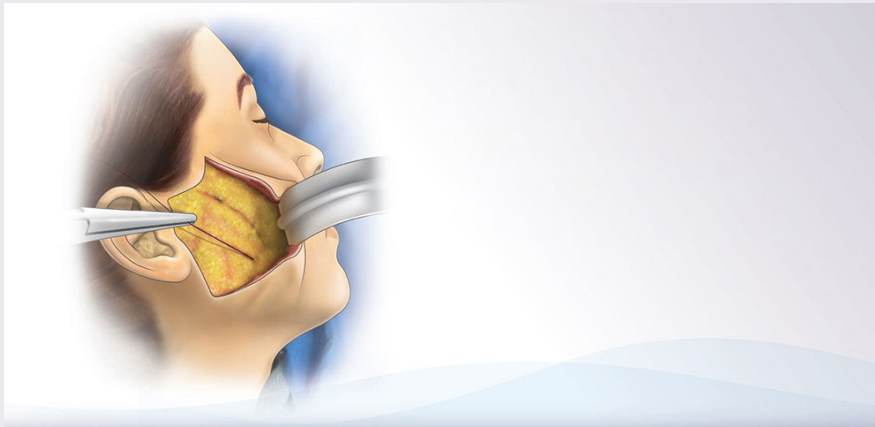
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CHAPTER 74 Facelift

Joe Niamtu, III



SUMMARY

- Rhytidectomy is a powerful procedure for face and neck rejuvenation.
- Shortcut procedures generally yield shortcut results.
- Combining facelift with other treatments, such as blepharoplasty and skin resurfacing, is ideal.
- Anesthesia options include tumescent anesthesia, sedation, and general anesthesia.

Beginner Tips



- Addressing the SMAS is absolutely critical for long-term cosmetic improvement.
- SMAS plication is generally the simplest approach.
- Do not overcut the flap when delivering the ear.

Expert Tips



- SMAS plication vectors may have a profound impact on ultimate cosmesis and avoiding the windblown effect.
- Midface augmentation can be accomplished by wisely choosing SMAS plication vectors and locations.

Don't Forget!



- Meticulous suturing technique will help minimize the appearance of postoperative scarring.

- Bevel the incision in hair-bearing areas to permit natural postoperative hair growth.

Pitfalls and Cautions



- A thorough understanding of multiple anatomical danger zones is an absolute prerequisite for facelift surgery.
- Patients must be warned regarding the risk of permanent nerve damage and other serious postoperative complications.

Patient Education Points



- Controlling patient expectations is critical.
- Facelift itself does not address wrinkles; always consider concomitant or serial resurfacing.
- An enlarging hematoma is a surgical emergency and the patient must call immediately if they notice undue swelling.
- A reliable and helpful caregiver at home is a must.

Billing Pearls



- Patients may benefit from combining facelift with other procedures, and sometimes they can see cost savings by doing this.
- Significant patient savings in anesthesia and facility costs can be seen when combining procedures.

CHAPTER 74 Facelift

INTRODUCTION

Facelift is a misunderstood word, with different meanings to different patients and surgeons. Cervicofacial rhytidectomy was described a century ago, and its basic principles remain unchanged. As with all procedures, surgeons have attempted to change the procedure to make it easier, less invasive, faster—or simply for hype. If patients have excess skin in the jowls and neck and platysmal banding, there is no contemporary procedure that can match the degree of improvement, natural appearance, and longevity of a standard cervicofacial rhytidectomy.

Shortcut procedures generally produce shortcut results, and this principle certainly applies to facelift surgery. Although minimally or less invasive facelift techniques exist, they are rarely appropriate for patients in their fifth and sixth decades. Small lifts provide small results, and performing a small lift on a patient that needs a more substantial lift—something applicable to almost anyone over 50—may provide disappointing results.

Traditional facelifts leave incisions in the sideburn, in front of and behind the ear, and under the chin. Less invasive facelifts (frequently referred to as “short scar” lifts) generally do not have postauricular and submental incisions, and are therefore limited in their ability to properly address the neck. While not every patient needs a traditional facelift, most candidates for a facelift procedure would likely benefit from a traditional facelift.

The typical facelift candidate presents with a chief complaint of excess neck skin and jowling. Many patients concomitantly address other aging changes with blepharoplasty ([Chapter 73](#)), chemical browlift ([Chapter 57](#)), injectable facial implants ([Chapter 58](#)), and skin resurfacing ([Chapter 67](#)), techniques which are addressed in detail in their respective chapters.

PREOPERATIVE CAVEATS

Facelift anesthesia

Although some surgeons perform facelifts with local or tumescent anesthesia, most surgeons with large facelift practices perform the surgery with deep IV sedation or intubated general anesthesia. Dermatologists historically exhibit expertise with tumescent techniques. This may be acceptable for some patients, but larger lifts may require deeper anesthesia.

Health history

As with any elective surgery, patients must be healthy enough for surgery and anesthesia. Extensive flap undermining can be complicated by bleeding (hematoma), smoking (necrosis), and systemic medications. Patients with obesity, systemic comorbidities, or a history of anesthesia-related complications must have a comprehensive medical workup performed prior to surgery. All medications that affect platelet function are typically stopped several weeks prior to surgery.

Patient expectations

A facelift will improve excess neck skin, jowling, and platysmal banding. It will not address the central oval of the face, perioral wrinkles, periorbital wrinkles, or forehead wrinkles. Patients with large skin and/or fat excess or those with weak chins or oblique submental anatomy may have less impressive results. A true facelift will generally last a decade if performed in a comprehensive manner. In some patients, the result may last longer, while in others the effects may wane more rapidly, depending on lifestyle, heredity, and maintenance.

It is important that patients appreciate that a facelift is not a procedure designed to treat wrinkles. Although some facial and neck wrinkling will be improved, concomitant or post-facelift skin resurfacing is generally required. Facelift surgery can be very comprehensive, and complications may include nerve and vessel damage, hematoma, flap necrosis, lack of anticipated result, and relapse. A comprehensive, informed consent process (see [Chapter 3](#)) is

an absolute prerequisite. It is imperative that any cosmetic surgery patient understands what their procedure will and will not accomplish.

THE PROCEDURE

Preoperative marking

Facelift patients should be marked in the upright position before any local or tumescent injection. For traditional facelift, a midline mark is made at or just below the submental crease for liposuction, platysmaplasty, or chin implant. The preauricular incisions made just inside the hairline of the sideburn follow the curvilinear preauricular anatomy, extend around the lobe, and remain in the postauricular sulcus. At the greatest width of the pinna, the incision should gently taper posteriorly and inferiorly, following the occipital hairline, just inside the hairline. The extent of the hairline incision is commensurate with the amount of neck skin excess for any given patient.

Anatomic considerations

No surgeon should ever undertake a procedure without a thorough working understanding of the related anatomy. It is assumed that surgeons reading this chapter have a basic knowledge of cutaneous surgical techniques and relevant anatomy such as the facial nerve branches, the greater auricular nerve, and the superficial veins of the neck such as the external jugular and anterior jugular veins and the parotid and submandibular glands (Fig. 74-1).

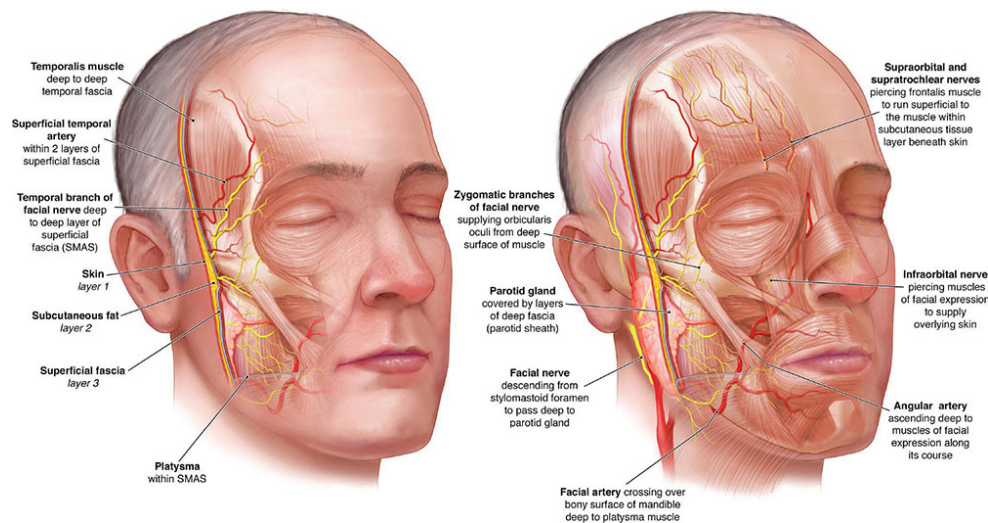


Figure 74-1. Critical anatomy for rhytidectomy procedures. (By permission of Mayo Foundation for Medical Education and Research. All rights reserved).

Planning

Many facelift patients undergo additional procedures, such as browlift, blepharoplasty, facial implants, or skin resurfacing. An uncomplicated facelift in the hands of an expert may be performed in 2 hours. Adding simultaneous procedures can double the surgical time, and novice surgeons should begin with facelift only. If other procedures are to be performed, they can be staged to the desire of the surgeon. I classically perform brow and eyelid surgery first, followed by the lift, cheek implants, and laser resurfacing.

Step one: Midline platysmaplasty

Table 74-1 summarizes the surgical steps in the standard facelift procedure. After waiting sufficient time for the tumescent anesthesia to take full effect, the procedure is begun with the submental incision, assuming platysmaplasty is planned. Liposuction is performed before or after the skin incision and dissection depending on surgeon preference.

Table 74-1. Surgical Steps in the Standard Facelift Procedure

Step 1: Midline platysmaplasty
Step 2: Pre- and postauricular incisions
Step 3: Flap dissection
Step 4: Addressing the platysma and SMAS
Step 5: Skin cutbacks and lobe delivery
Step 6: Skin excision
Step 7: Skin closure
Step 8: Postprocedure protocol

It is important to keep the incision at or slightly below the submental crease and horizontally level. A skewed incision in this region is very noticeable. The incision extends to the subcutaneous plane and scissor dissection is begun (Fig. 74-2). It is important to leave several millimeters of subcutaneous fat on the underside of the dermal surface. The extent of the dissection is commensurate with the amount of aging and skin excess. The average undermining extends from the mandibular border to the thyroid cartilage, and laterally to the sternocleidomastoid muscle region bilaterally. Most patients have significant fat excess that necessitates liposuction, generally performed under direct visualization. Subplatysmal fat is not generally addressed unless extremely excessive.

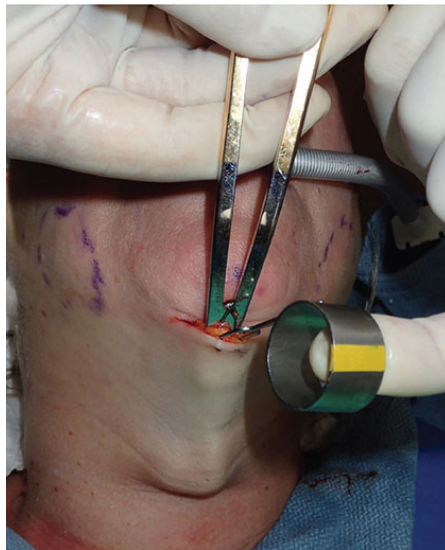


Figure 74-2. The left image shows the subcutaneous dissection through the submental crease and the right image shows open liposuction of the submental region.

The medial platysmal borders are then identified. If significant laxity exists, the medial borders can be trimmed laterally to eliminate muscle excess. Horizontal mattress sutures are then placed from the most inferior accessible region (usually between the thyroid cartilage and hyoid bone) and continued along in an equally distributed fashion to the mandibular border. In general, five to seven 2-0 Vicryl sutures are placed.

Step two: Pre- and postauricular incisions

The preauricular incision is begun at the sideburn region. All hairline incisions are made with the scalpel at an extreme bevel of approximately 20 degrees. This transfollicular (or trichophytic) type of incision purposely transects several rows of distal hair follicles, leaving intact bulbs that will regrow through the scar (**Fig. 74-3**).

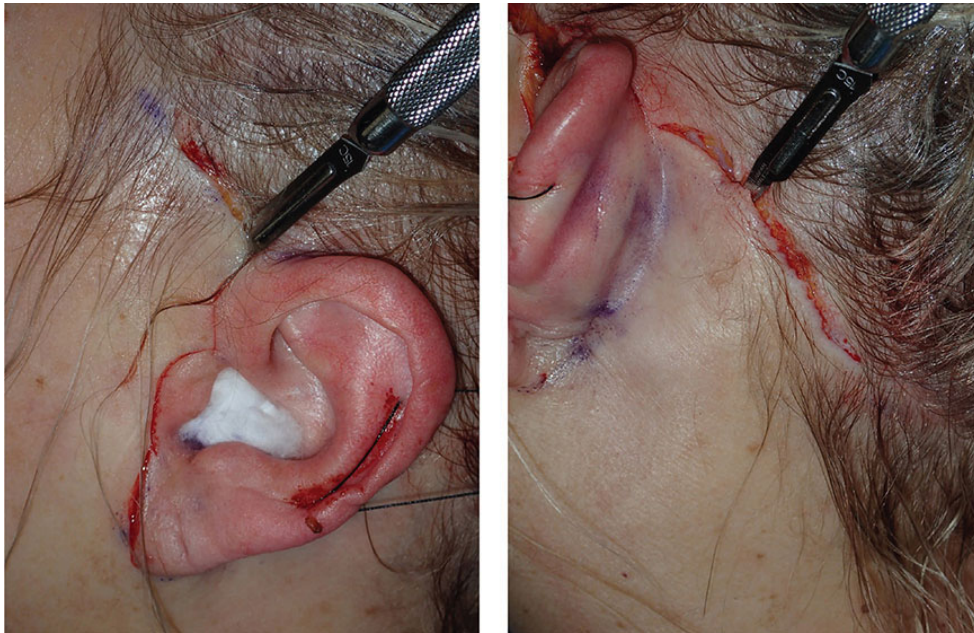


Figure 74-3. Demonstration of the hyperbeveled transfollicular incision in the hair-bearing regions.

The incision now navigates the helical attachment, and these non-hair-bearing skin incisions are made in a conventional manner without beveling the incision. The incision follows the helical attachment and then proceeds in

a pre- or posttragal fashion depending upon operator preference. Pretragal incisions may be curvilinear, and posttragal incisions follow the tragal anatomy (Fig. 74-4). The incision then continues at the junction of the lobe and cheek, around the back of the lobe, and into the postauricular sulcus. The sulcular incision is continued to the greatest width of the ear (to hide the incision behind the pinna), and then tapers along the occipital hairline. This hairline incision is made just into the hair follicles as previously described for the sideburn (Fig. 74-5).

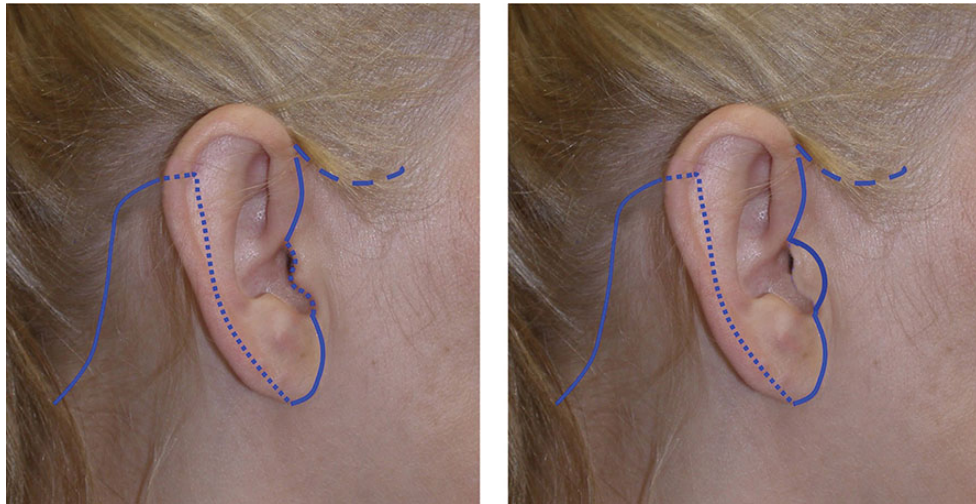


Figure 74-4. This image shows the typical incisions used by the author in facelift surgery. The left picture is retrotragal and the right picture is pretragal.



Figure 74-5. Typical facelift incisions are shown.

Step three: Flap dissection

After the incisions are completed, the flap dissection is begun. This is a lipocutaneous flap, and it is important to leave several millimeters of fat on the dermal side of the flap, and treat all flaps gently to preserve the dermal plexus of nourishing vessels. Specialized facelift scissors may be used to

clip and spread in the subcutaneous plane (Fig. 74-6). Again, there should be fat both above and below the dissection plane. Flap undermining distance is commensurate with the amount of aging and skin excess. The average facelift flap is dissected 5 to 6 cm circumferentially around the ear (Fig. 74-7). Having the assistant stretch the area of dissection may be helpful to maintain all dissection in the correct plane. The surgeon can also grasp the flap edge with a hemostat or skin hook and pull in a direction opposite of the scissors to facilitate dissection. The preauricular flaps are ultimately connected with the platysmaplasty dissection to create a single large flap under the chin from ear to ear. This allows more skin to be undermined and repositioned for a tighter and longer-lasting result (Fig. 74-8).

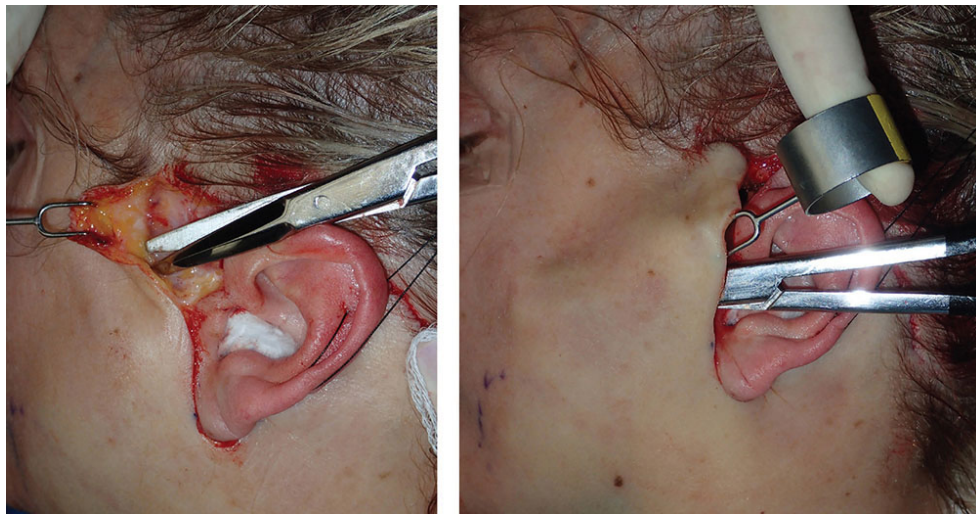


Figure 74-6. The left image shows the initial dissection in the subcutaneous plane and the right image shows the extent of dissection in a typical medium-sized facelift.



Figure 74-7. This image shows a typical anterior and posterior facelift flap dissection.



Figure 74-8. This image shows the connection progressing from the cheek flap to the submental dissection.

Most surgeons treat the platysma, then proceed to one side of the face, and finally finish with the other side. My preference is to dissect all flaps serially, then perform all plication, and finally perform all suspension and skin removal, as this approach may decrease the forces that lead to surgical relapse.

Meticulous hemostasis is obtained throughout the entire procedure.

Step four: Addressing the platysma and SMAS

After subcutaneous dissection and liposuction, a midline corset platysmaplasty is performed by plicating the dehiscenced platysma borders in the midline ([Fig. 74-9](#)). In cases of excessive platysma dehiscence, some of the medial platysma can be removed.

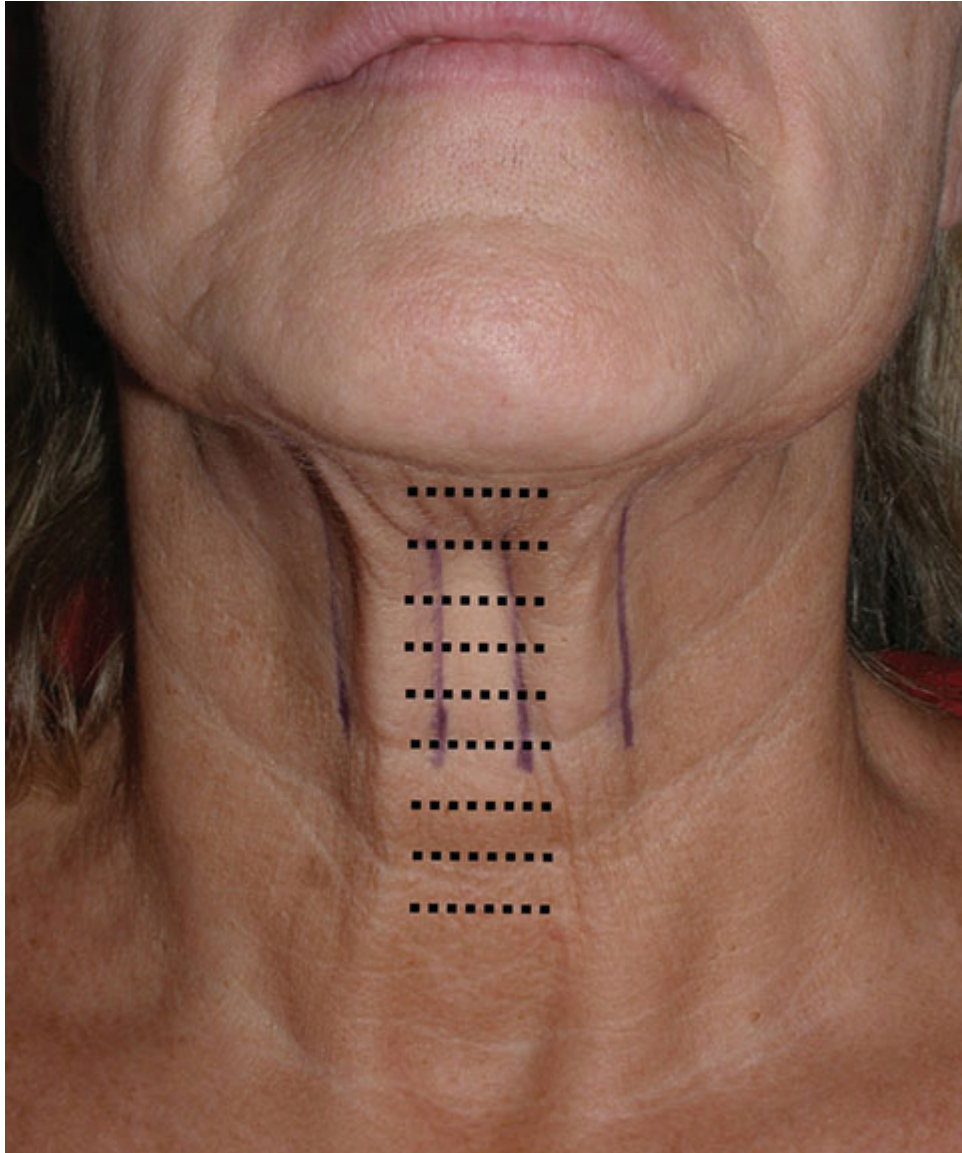


Figure 74-9. This image shows the approximate location of the platysma plication sutures.

The superficial musculoaponeurotic system (SMAS) is a controversial histologic layer lying deep to the dermis and superficial to the parotidomasseteric fascia. The parotidomasseteric fascia is an important landmark, covering the parotid gland and masseter muscle. The facial nerve branches emerge at the anterior border of the parotid gland and lie directly deep to the parotidomasseteric fascia. At this point the facial nerve branches cross the surface of the masseter muscle. Novice surgeons should always operate over the body of the parotid gland and avoid the anterior portion where the nerves are vulnerable.

The SMAS requires some method of tightening, which may be accomplished by plication, SMASectomy, SMAS flap, subSMAS dissection, or purse-string sutures. While I routinely perform SMASectomy, simple SMAS plication is the safest and easiest technique for novice surgeons.

SMAS plication is performed by grasping the SMAS layer lateral to the oral commissure and securing it in a superolateral vector anterior to the tragus (Fig. 74-10). The first suture (2-0 Vicryl) is placed midway between the oral commissure and earlobe. This suture will “reset” the deep tissues of the ptotic jaw and neck. Next, several 2-0 Vicryl sutures are placed above and below the primary suture to lift the ptotic tissues and strengthen the suspension. In general, 4-5 SMAS plication sutures are placed in the preauricular region.

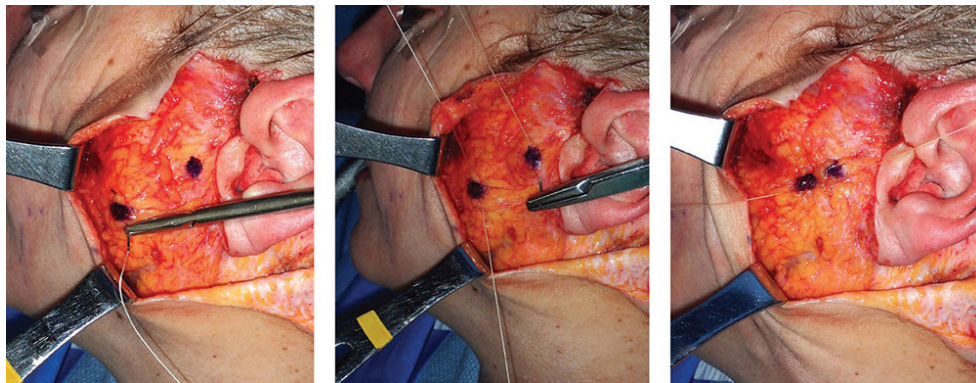


Figure 74-10. A SMAS plication is shown as a 2-0 Vicryl mattress suture is placed in the SMAS lateral to the level of the oral commissure in the direction of the tragal region.

The last step in the suspension portion of the facelift is to place posterior (also called lateral) platysma sutures that will pull the lateral border of the platysma to further define the neck and mandibular border. A single 2-0 Vicryl suture is placed in the posterior platysma inferior to the angle of the mandible. The suture is then stretched in a superolateral vector and the other end secured to the mastoid fascia (Fig. 74-11). A second suture is placed below this in the midneck in the same manner. It is important to avoid the external jugular vein in this area.

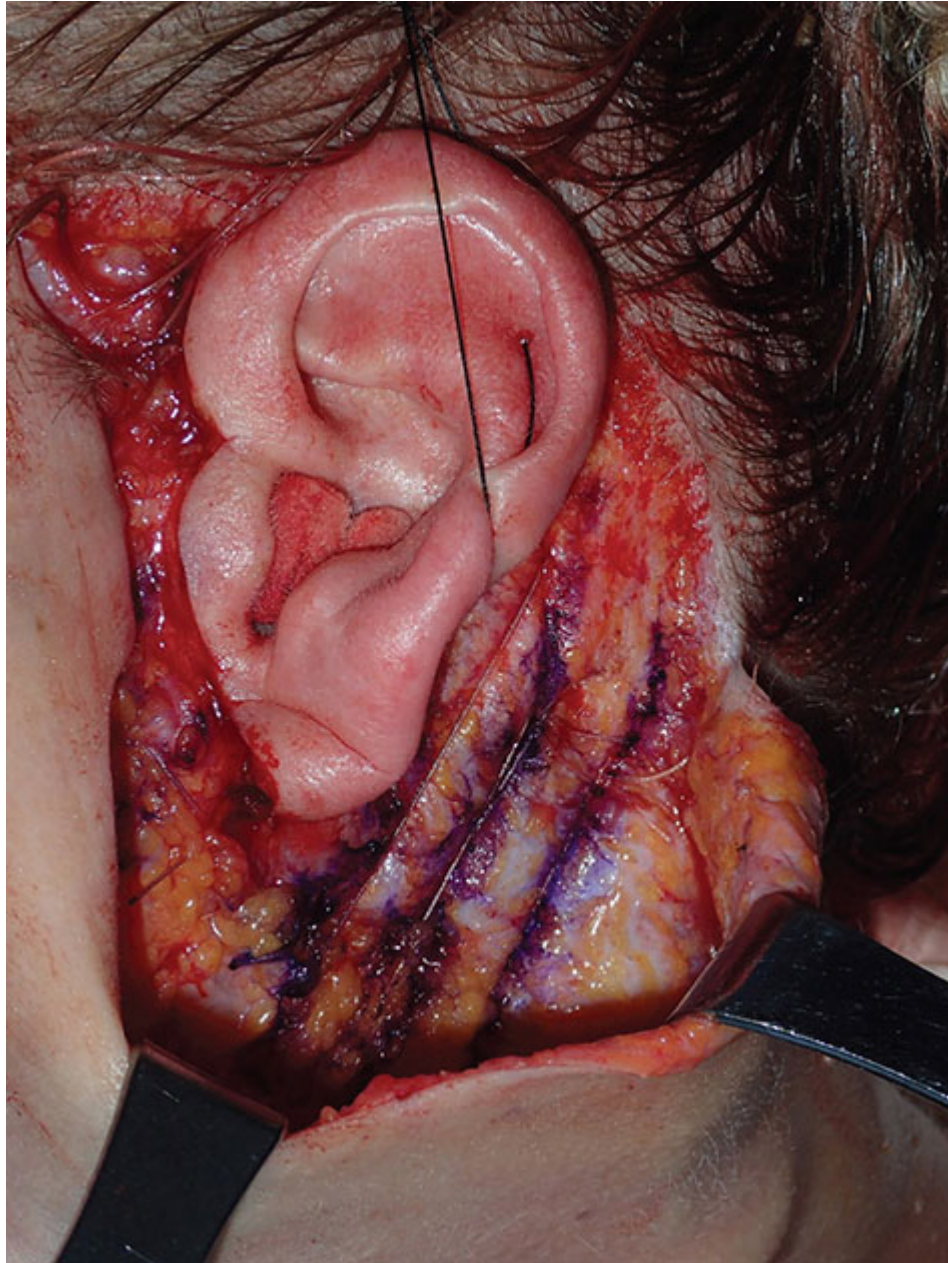


Figure 74-11. This image shows a posterior platysma plication suture which secures the lateral platysmal border and engages the mastoid fascia. This provides an additional level of deep tightening.

Step five: Skin cutbacks and lobe delivery

After the platysmaplasty and dissection with SMAS treatment, the first side of the lift is suspended and trimmed. Skin cutbacks are generally made in the sideburn and superior sulcus regions ([Fig. 74-12](#)).



Figure 74-12. This image shows the front and back key sutures and the degree of skin excess in a medium-sized facelift.

This skin is pulled tightly with these sutures as they are the only skin sutures that will bear tension in the operation. 4-0 Vicryl is used to place “key” sutures in front of and behind the ear. This is best accomplished with the head in the vertical position (direct AP position), and serves to make the

cutbacks more accurate by diminishing the distracting forces on the skin that occur with the head turned to one side.

At this point, the earlobe is delivered from under the flap. In smaller lifts, it can simply be teased out, while larger lifts require an incision of the flap to deliver the lobe. Overcutting the lobe delivery incision is one of the most common mistakes in facelift surgery, and can lead to a pixie lobe deformity, where the earlobe is distorted and elongated inferiorly. If the surgeon feels that this incision should be 10 mm, then he or she should cut it 3 to 4 mm. Always be conservative with this incision, as it is very easy to deform the lobe by overcutting (Fig. 74-13).

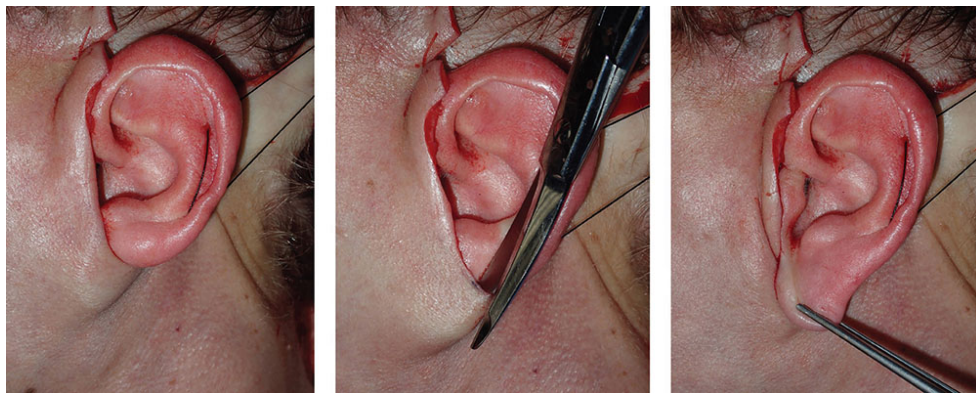


Figure 74-13. In smaller cases the lobe can be delivered without any skin cutback. This case illustrates the sequence of earlobe delivery. It is important to be very conservative with this incision, as overcutting the flap will pull the lobe into a pointed “pixie ear” deformity.

Step six: Skin excision

The skin excision phase removes excess skin that has overlapped the incision after key suture retraction and stabilization, and can be performed with scalpel or scissors. When trimming hair-bearing incisions, the scalpel is once again beveled to the same angle as the initial incision to allow a thin interface at the incision junction which permits easier regrowth of the hair follicles through the incision. In the perfect facelift incision, hair remains on both sides of the incision line.

The remainder of the anterior and posterior auricular skin excess is removed as accurately as possible leading to a passive interface (Fig. 74-14). Wound tension will create unfavorable scars, and all incision interfaces must be closed without tension.

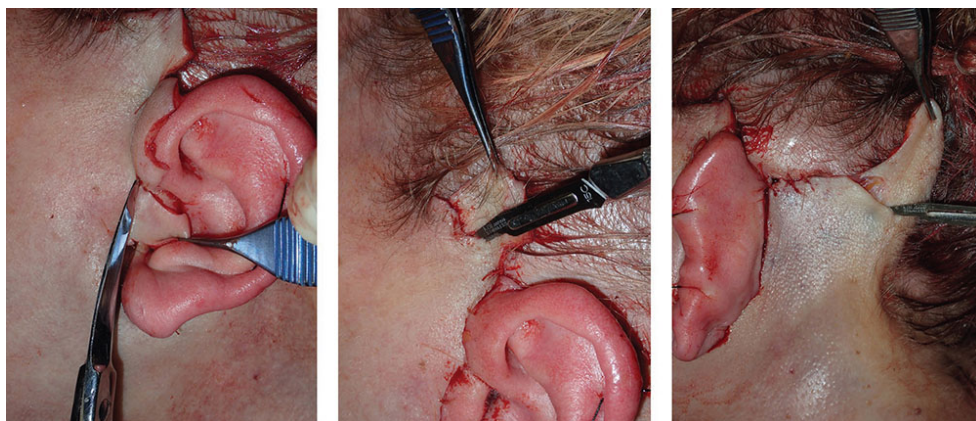


Figure 74-14. This image shows excision of excess skin at the tragus, sideburn, and posterior auricular regions.

Step seven: Skin closure

Many surgeons use staples to close hair-bearing incisions, although I prefer 4-0 or 5-0 gut suture. I prefer 5-0 gut for the preauricular incisions and 4-0 gut for the lobe, sulcus, and occipital hairline incision closure. Although many surgeons use subcutaneous sutures for closure, I do not. The final closure is shown in [Figure 74-15](#).



Figure 74-15. This image shows the final closure (with some sutures not placed yet) of the front and back incision.

It is important to reposition the earlobe in a passive normal position so it is not retracted or pulled in an unnatural direction.

At this point, the same surgical procedure is performed on the contralateral side.

Step eight: Postprocedure protocol

At the end of the procedure the hair is washed with hydrogen peroxide and sterile saline and combed out to free tangles and debris. Many surgeons use suction drains, such as a Jackson–Pratt drain, although the author prefers to simply place 14-gauge IV catheters in the midportion of the subcutaneous plane in the lower confines of the neck flap bilaterally and leave them in place for 24 hours (Fig. 74-16).



Figure 74-16. A 14-gauge IV catheter on each side of the submandibular region may be placed for 24 hours to allow passive drainage.

Most surgeons use a full head wrap postsurgical dressing. I have abandoned this and do not routinely use any dressings, as many of my facelift patients undergo simultaneous laser resurfacing. Although I have described multiple steps that I omit, it is best for novice surgeons to follow common protocol until their experience increases. A common facelift dressing can be placed by putting antibiotic ointment on gauze over the incisions, and placing gauze fluffs over all undermined flaps (or a pad across the submental region). An elastic Velcro head wrap or elastic stretch tape (Coban) can then be used to lightly compress (never heavy compression) the underlying gauze and

surgical sites (Fig. 74-17). If a dressing is used, it is preferable to use the Velcro type as it can easily be removed for inspection and replaced.



Figure 74-17. A typical post-facelift dressing consists of gauze pads over all incisions and flaps covered with an elastic compression dressing. Only minor compression is required, and excessive compression can damage the delicate flaps.

Postoperative treatment

Patients are generally given prescriptions for antibiotics, analgesics, antiemetics, and a steroid regimen (Table 74-2). An understanding, available, and competent caregiver at home during the course of recuperation is of paramount importance.

Table 74-2. Standard Postoperative Medication Regimen for the Facelift Patient

Pain: Hydrocodone followed by acetaminophen

Edema: Oral prednisone 60 mg once daily for 5 days

Infection: Oral cephalosporin for 1 week

Antiemetic: Scopolamine patch the night before surgery
and ondansetron prn

Patients are seen the following morning and the dressings are removed. Flaps are inspected for viability and hematoma or seroma formation, and any visible fluid collections are aspirated. If dressings are to be continued, a less bulky dressing is generally placed. The IV catheter “vents” are also removed at this appointment.

Patients are then seen at 1 week, 2 weeks, 1 month, and 3 months postoperatively. [Figure 74-18](#) shows two patients with differing postoperative recovery responses.



Figure 74-18. The top picture shows a younger patient with a typical 24-hour facelift postoperative appearance. The male in the bottom picture shows more pronounced bruising 72 hours post facelift.

Post-Facelift complications

Hematoma is the most common immediate post-facelift complication and must be treated as an emergent situation (Fig. 74-19). Small collections can be aspirated, but expanding hematomas can cause airway compromise and flap necrosis.



Figure 74-19. This patient is shown 7 hours after her facelift surgery with a right-sided hematoma. The “currant jelly” hematoma is shown after opening the incisions. This must be evacuated and all bleeding controlled.

Other complications include loss of flap perfusion and necrosis, infection, bleeding, nerve damage, poor scarring, and substandard result with resultant skin laxity or excess.

CONCLUSIONS

A well-performed facelift is one of the most powerful aesthetic procedures available to the dermatologic surgeon, and—particularly when coupled with other rejuvenation techniques such as skin resurfacing and blepharoplasty—has the potential to dramatically affect the patient’s quality of life (Figs. 74-20 to 74-27). The power of an outstanding outcome must, however, be

weighed against the risks of the procedure, and therefore an exhaustive informed consent process, including the potentially severe consequences of undesirable outcomes, must be undertaken with each patient.



Figure 74-20. This patient is shown 6 weeks after facelift with simultaneous chin implant.



Figure 74-21. This patient is shown 3 months after facelift with simultaneous chin implant and full face laser skin resurfacing.



Figure 74-22. This patient is shown 3 months after facelift with simultaneous full face laser skin resurfacing.



Figure 74-23. This patient is shown 3 months after facelift with simultaneous chin implant.



Figure 74-24. This patient presented post bariatric surgery with a 100-lb weight loss and is shown 3 months after facelift.



Figure 74-25. The patient illustrates the power of combined rejuvenation procedures. She is shown 3 months after facelift with simultaneous upper and lower blepharoplasty, cheek implants, and laser skin

resurfacing.



Figure 74-26. The male patient is shown before and 5 months after facelift.



Figure 74-27. The male patient is shown before and 3 months after facelift.

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Part VI

MANAGEMENT OF COSMETIC CONDITIONS

- 75 Approaches to Facial Wrinkles and Contouring
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CHAPTER 75 Approaches to Facial Wrinkles and Contouring

Vince Bertucci
Mohammad Almohideb
Kucy Pon



SUMMARY

- The past several years have seen a paradigm shift to viewing facial aging and the development of rhytides as a three-dimensional process.

- Rather than simply filling in facial creases, injectors now focus on volumizing and contouring the face to indirectly address the root cause of wrinkle formation.
- Judicious combinations of neuromodulators and fillers provide patients with a minimally invasive—though not risk free—approach to wrinkle reduction and contouring that may ultimately lead to an aesthetically pleasing outcome.

Beginner Tips



- Combined use of sharp needle injections and blunt microcannulas, depending on the site and treatment goals, may be used to achieve a balance of safety and efficacy.
- Beware overtreatment of lateral canthal rhytides with botulinum toxin in order to avoid creating an unusual smile with a shelf-like appearance and overprojection of the cheeks anteriorly.
- Prior to injecting, palpate and avoid the temporal artery and slowly aspirate on the needle plunger to minimize the risk of intravascular placement; keep in mind that a negative aspiration test does not guarantee nonintravascular placement.

Expert Tips



- Deeper filler placement is less effective in the submalar area due to the lack of bony support.
- BTX-A may be suitable for treating hyperdynamic “accordion” cheek lines with one to six units of intracutaneous BTX-A to each side. This can be achieved by one to two injection points over the mid-to-lateral malar eminence.
- When injecting fillers in the tear trough, undercorrection is advocated, as the hygroscopic nature of HA fillers makes this area prone to edema, bulging, and the Tyndall effect.

Don't Forget!



- The global aesthetics consensus recommends the following toolkit for managing HA filler complications: hyaluronidase, oral and intralesional steroids, empiric antibiotics (minocycline, ciprofloxacin, or clarithromycin), antiviral agents, topical nitroglycerin (1%), antihistamines, aspirin 325 mg orally, warm compresses, bacterial culture kit, and phone numbers of prearranged referrals (e.g., ophthalmologists, hyperbaric oxygen).
- Err on the side of underdosing perioral BTX.

Pitfalls and Cautions



- With filler injections, the highest risk of blindness and changes is in the glabella (38.8%) followed by the nasal region (25.5%), nasolabial area (13.3%), and forehead (12.2%).
- Avoid overcorrection of the jawline so as to prevent masculinization of the female face.
- Avoid completely effacing the nasolabial folds, and preferentially augment the cheek prior to considering direct fold injection.
- Extra care should be taken for nasal dorsum fillers.
- BTX-A injections should be placed higher on the forehead to minimize the risk of eyebrow and eyelid ptosis.

CHAPTER 75 Approaches to Facial Wrinkles and Contouring

INTRODUCTION

The quest for beauty is an age-old human desire; indeed, this yearning is hardwired into the brain, partly to increase the likelihood of success in the search for a fertile mate for reproductive purposes and ultimately for overall species survival. This genetic drive, coupled with the influence of popular media on the perception of attractiveness, has contributed to the wish to enhance attractiveness and achieve an aesthetically appealing appearance. Facial volume depletion, contour alterations, and cutaneous rhytides, combined with other changes, have long been viewed as characteristic signs of aging and a commensurate decline in attractiveness.

Numerous developments have occurred in an attempt to promote natural appearance and facial harmony, as well as balance and proportion. While invasive approaches have historically played a large role in facial beautification and enhancement, noninvasive soft-tissue augmentation and muscle neuromodulation have revolutionized modern aesthetic medicine. The notion of facial beautification and management of facial wrinkles has evolved through many different phases of innovation spanning over a century, becoming more sophisticated as our understanding of beauty and aging has become more nuanced.

The therapeutic use of botulinum toxin was first envisioned in 1820 by Justinus Kerner, though he did not envisage a cosmetic application.^{1,2} It was not until 1987 that Dr. Jean Carruthers and Dr. Alastair Carruthers

discovered the cosmetic benefits of botulinum toxin A (BTX-A) in patients with blepharospasm. Their publication on the use of BTX-A for glabellar rhytides sparked additional research for additional indications.⁴⁻⁹ In the realm of volume restoration, Neuber attempted to restore facial volume loss as early as 1893 by using autologous fat taken from the upper arm to reconstruct facial defects in tuberculosis patients. In 1899, Gersuny utilized liquid paraffin, though ensuing granulomas, skin ulceration, and necrosis led to the abandonment of its use. In the 1960s, silicone oil became popular for facial injections and was eventually banned by the U.S. Food and Drug Administration (FDA) due to complications similar to paraffin.^{10,11} In 1981, the FDA-approved bovine collagen for cosmetic injections, ushering in an era of new soft-tissue filler development and, perhaps more importantly, an era of greater understanding of facial beauty and aging. A number of hyaluronic acid (HA) fillers have since been approved in the United States, starting with Restylane® (Galderma) in 2003. While other countries have seen approval of dozens of HA products, the number approved in the United States is significantly lower.

Irrespective of site-specific indications, soft-tissue augmentation and neuromodulator treatments can be thought of as having three main indications: beautification, restoration of normal anatomy (whether due to aging, trauma, or lipodystrophy), and prevention of wrinkling. While the early emphasis was on a two-dimensional approach, recent years have seen a paradigm shift to a three-dimensional approach that addresses not only facial lines and wrinkles, but also soft-tissue volume loss and bony remodeling.¹²

The popularity of cosmetic procedures is rapidly increasing. In 2015, according to the American Society for Aesthetic Plastic Surgery, Americans spent over 13.5 billion USD on surgical and nonsurgical cosmetic procedures. Nonsurgical procedures accounted for 42% of the total expenditure, an increase of 18.9% from 2014. Botulinum toxin has remained the most commonly performed nonsurgical procedure in the United States since 2000, accounting for 39.2% of all on-surgical procedures in 2015. HA injectables were the second most popular procedure performed, accounting for 19.75%, an increase of 26.6% over 2014.¹³ In addition to aesthetic benefits, botulinum toxin and soft-tissue filler treatments have been

associated with a more positive mood, increased level of satisfaction, and overall improved quality of life.^{8,14-21}

For simplicity, the face may be divided into thirds, including the upper third (from the hairline to the upper eyelids), middle third (from the lower eyelids to the nasolabial angle), and lower third (from the cutaneous upper lip to the mandibular border). Each of the thirds may be further divided into subsections.

FILLER AND BOTULINUM TOXIN TYPES

The FDA has approved 23 injectable fillers. Fillers can be categorized into either HA, bovine and human collagen, calcium hydroxylapatite (CaHA), poly-L-lactic acid (PLLA), or polymethylmethacrylate (PMMA).²² Fibrel is a mixture of plasma, porcine-derived gelatin, and ε-aminocaproic acid that is not commercially available and approved by the FDA for depressed scars and rhytides. Mesenchymal stem cell transplantation,²³ autologous cultured fibroblasts transplantation (LaViv, Fibrocell Science, Inc.),²⁴ polyalkylimide, silicone, silicone gel, silicone particles suspended in a polyvinylpyrrolidone carrier, porcine collagen, Cymetra, Dermalogen, AlloDerm, and expanded polytetrafluoroethylene are other fillers that are not commonly used.

Fillers may also be classified as either permanent or temporary depending on their duration of effect. Silicone and PMMA are examples of permanent fillers. CaHA, PLLA, autologous fat, porcine and bovine collagen, and HA are a few examples of temporary fillers.

FDA-approved botulinum toxin products include onabotulinumtoxin A (Botox and Botox Cosmetic, Allergan, Inc.), abobotulinumtoxin A (Dysport, Ipsen Biopharm Ltd.), incobotulinumtoxin A (Xeomin, Merz), and rimabotulinumtoxin B (Myobloc, Elan Pharmaceuticals).²⁵ The former three Botulinum toxins are used for aesthetic purposes in the United States. Globally, botulinum toxin can be found as Lantox, Prosigne, Neuronox, Siaz, Neurobloc, PurTox, CBTX-A, Botulift, Botulax, Cunox, Meditoxin, and Otesaly, to mention a few.

FILLER SELECTION CONSIDERATIONS

Several general concepts may help in choosing the appropriate filler type and injection technique.

1. Patient characteristics: Age, ethnicity, skin thickness and quality, adipose tissue thickness, underlying structural support (e.g., bone, teeth, cartilage, muscle), degree of skin sagging and elasticity, skin mobility, underlying comorbid conditions, medications, allergies, and pregnancy/lactation status.
2. Product characteristics: Cohesivity, lift capacity, ease of injection, tissue integration, malleability/sculptability, concentration, particle size, cross-linking technology and density, presence of lidocaine, and cost.¹²
3. Goal of treatment: Discussion with the patient and counseling is essential in deciding whether to choose permanent, semi-permanent, or temporary fillers for volumizing, rejuvenating, or contouring of the areas of interest. Prioritizing treatment areas is also key if one is to deliver excellent results in a cost-effective manner. One of the key foundational skills required to achieve outstanding outcomes is the ability to assess the face and formulate a prioritized treatment plan based on the patient's unique needs. It is important to note that what the patients "wants" does not necessarily coincide with what the patient "needs" to achieve the best, most natural results.

The physicochemical properties of a filler determine its lift capacity. Fillers are characterized by their deformation and flow properties, commonly known as rheological properties. Filler rheology is often used to predict clinical performance. The elastic modulus (G'), cohesivity/viscosity, and water uptake are of importance in determining filler selection. Higher G' is associated with higher lift capacity and stiffer fillers. Viscosity is the ability of a filler to resist tissue spread. More viscous fillers tend to have higher G' and are more suited to resist gravitation-related changes, whereas less viscous fillers are suited for more delicate regions such as the periorbital area.²⁶ The global aesthetic consensus classifies HA fillers into deep, mid-level, or superficial volumizers with recommendations for implantation depth (Table 75-1).²⁷

Table 75-1. Typical Products in a Hyaluronic Acid Filler Family Designed for Layered Implantation, and Their Usual Implantation Depths^a

Product Type	Usual Implantation Depth
Deep volumizer	Supraperiosteal and subcutaneous
Midlevel volumizer	Subcutaneous and sometimes intradermal; submucosal to lips; supraperiosteal to nasojugal folds
Superficial volumizer	Intradermal and superficial subcutis; submucosal to lips; supraperiosteal to nasojugal folds
Additional specialty products	Lips, submucosal, nasojugal folds, supraperiosteal, and subcutaneous

*Sundaram H. Igniting discovery, dialogue, and global innovation through international collaboration. *J Drugs Dermatol*. 2013;13:386–388.

Soft-tissue filler injection technique options using a sharp needle include serial puncture with microdroplets, linear retrograde and anterograde threading, fanning, or cross-hatching (Fig. 75-1). In addition, the bolus or depot technique is commonly employed. Blunt-tipped cannulas may be less likely to puncture vessels and may reduce the risk of intravascular injection, bruising, discomfort, and number of injection sites; however, there is a learning curve with cannulas, so that precise product placement may be suboptimal initially. In addition, previous facial surgery, scarring, or tissue augmentation may contribute to tissue fibrosis, making use of a cannula more challenging.^{28,29} Combined use of sharp needle injections and blunt microcannulas, depending on the site and treatment goals, may be used to achieve a balance of safety and efficacy. A consensus panel of four authors has advocated for different blunt cannula sizes.²⁹ The authors' cannula preferences (Table 75-2) and entry points (Fig. 75-2) for the various facial regions differ slightly.

Table 75-2. Preferred Blunt Microcannulas for Specific Areas and Products

Area	Microcannula Diameter and Length	Preferred Filler Product(s)
Lower eyelid	27- or 25-gauge, 38 mm	HA
Upper eyelid and around eyebrow	27- or 25-gauge, 38 mm or longer	HA
Midface	25- or 22-gauge, 38 mm or longer	HA, CaHA, or PLLA
Temple	25- or 22-gauge, 38 mm or longer	HA, PLLA or CaHA
Lower face	25- or 22-gauge, 38 mm or longer	HA, CaHA or PLLA
Lips	27- or 25-gauge, 38 mm	HA
Hand (dorsum)	25- or 22-gauge, 38 mm or longer	CaHA or HA
Décolletage	25-gauge, 38 mm	HA

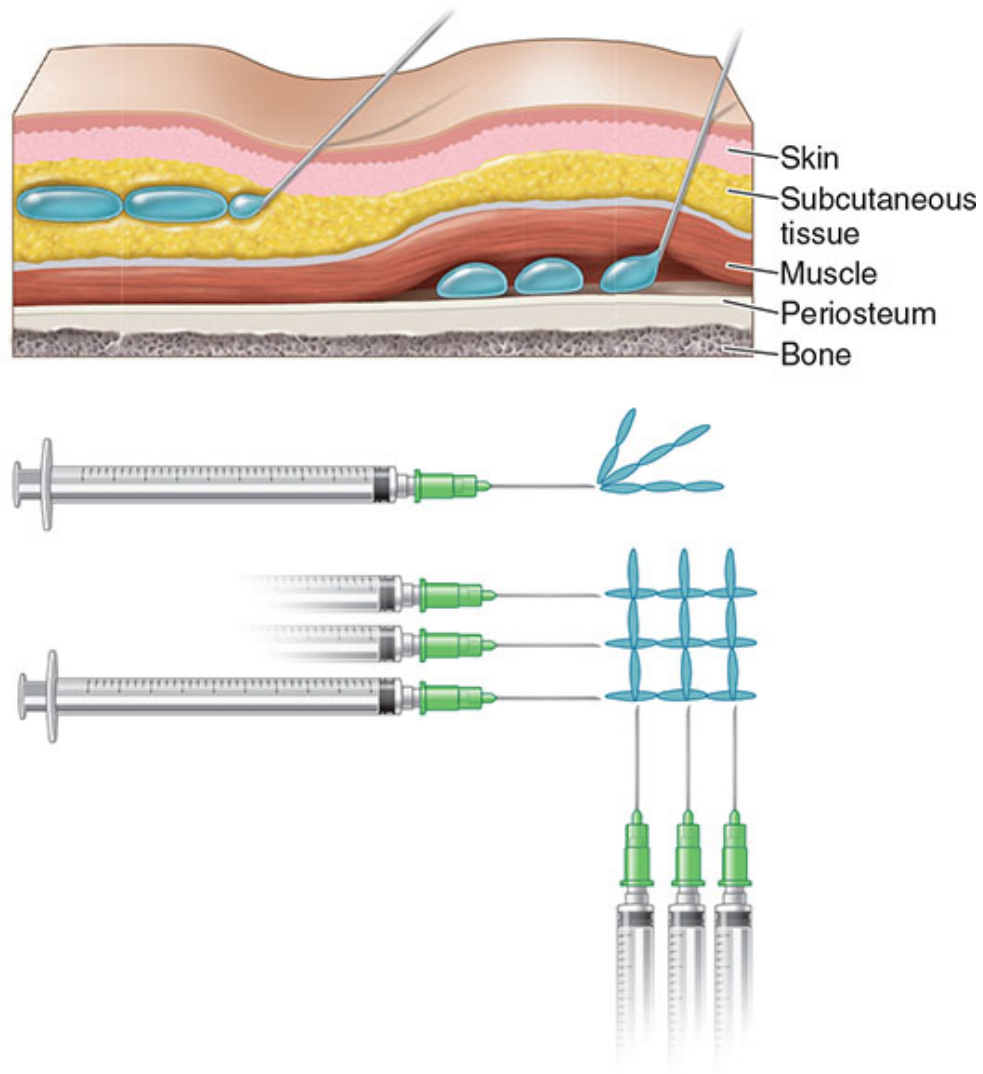


Figure 75-1. Soft-tissue filler injection technique options using a sharp needle include serial puncture with microdroplets, linear retrograde and anterograde threading, fanning, and cross-hatching.

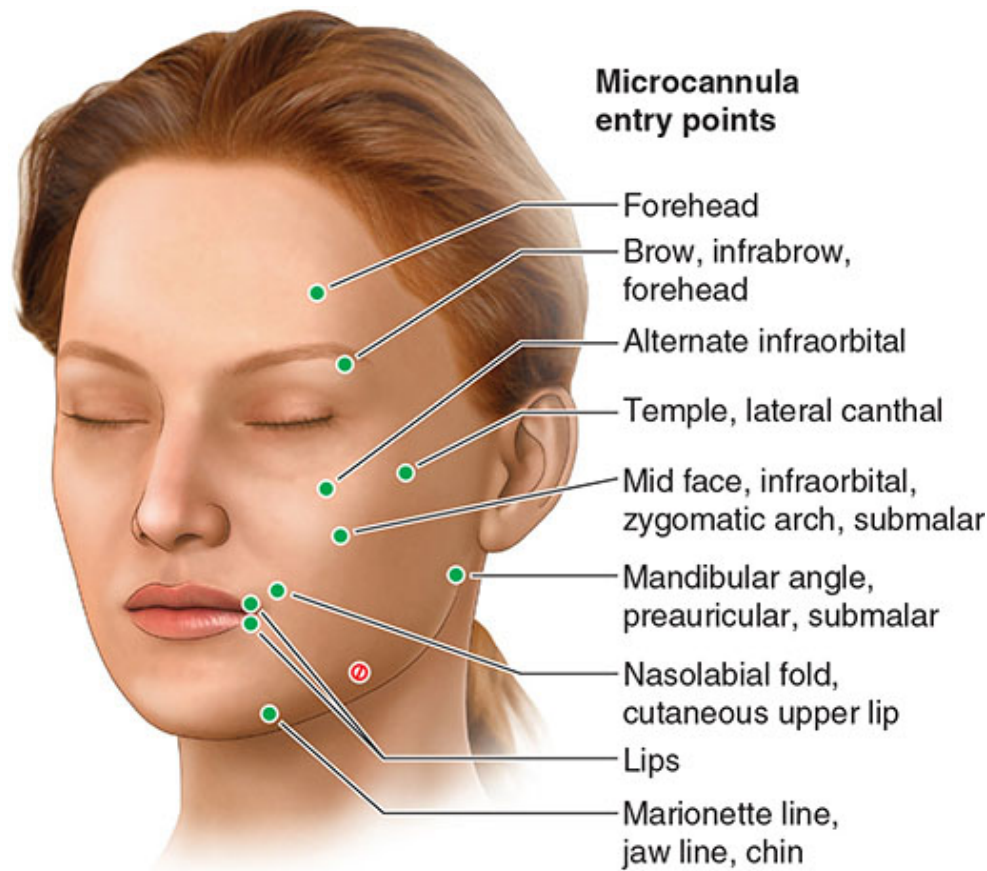


Figure 75-2. Select microcannula entry point suggestions.

UPPER THIRD OF THE FACE

Forehead

Indications

Combined facial aesthetic interventions are generally preferable in order to deliver optimal aesthetic results.³⁰ The forehead, glabella, and temples, which are often assessed as one cosmetic unit, may be treated with both BTX-A and soft-tissue fillers to achieve controlled muscle relaxation and softening of dynamic rhytides, as well as improved temporal and forehead contour, respectively. A split-face, rater-blinded, randomized control trial of 20 subjects demonstrated that combination treatment with fillers and BTX-A for glabellar and forehead lines may provide a slightly better cumulative

benefit and prolonged duration of effect.³¹ When treating these areas, the injector must possess advanced knowledge of forehead anatomy to reduce the risk of complications.³²

Fillers

In general, HA products that integrate well into the tissue are preferable for the forehead to avoid the appearance of lumps in this area that can sometimes have thin, atrophic skin. Specific product selection will depend on patient characteristics such as the amount of subcutaneous tissue, skin thickness, and degree of lift required. A consensus group for combined HA and BTX-A treatment prefers superficial Vycross/Hylacross or dilution–reconstitution of Hylacross products for rhytides and mid-level or diluted deep volumizer Vycross for contouring.²⁷ PLLA may also be used on the forehead, but care must be taken to use a high volume of reconstitution (14–16 mL) so as to minimize the risk of nodule formation.

It is not uncommon to see volume loss in the forehead over time. This may be manifest with mid-forehead or suprabrow (especially laterally) concavity. Slight forehead convexity is aesthetically appealing and can be achieved by injecting the area of concavity to improve the appearance of forehead volume loss, giving a more convex shape and sometimes providing brow lift as a result of volume restoration.

Filler placement can also benefit lateral eye projection and attenuate contour transitions between the temple and forehead region. The goal is to achieve a gentle convex curve that is 12 to 15 degrees off the vertical as one goes from the hairline to the supraorbital prominence.¹² Avoiding superficial injection of fillers that integrate poorly into tissue will minimize the risk of beading and visible overcorrection.

Forehead fillers may be injected using either a needle or cannula. When using a needle, it is placed deeply and small boluses of filler are injected in the subgaleal plane. When injecting deeply, it is important to avoid the region bounded by the midpupillary lines, the orbital rim inferiorly and a horizontal line drawn approximately 1.5 cm above the orbital rim. A cannula may also be used to inject the forehead, entering either just medial to the temporal suture line or just medial to the tail of the brow. Less experienced injectors may find this a challenging area to inject with cannulas, partially given the

lack of adipose tissue and resistance to cannula movement (Figs. 75-3 and 75-4).



Figure 75-3. Preprocedure photographs.



Figure 75-4. After treatment with botulinum toxin in the forehead, glabella, nasalis (bunny lines), lateral canthal rhytides, and mentalis and fillers in the forehead, infrabrow hollow (A-frame deformity), cheeks (upper medial, zygomatic arch, submalar), marionette lines, lips, and angle of mandible.

Botulinum toxin

The global aesthetics consensus recommends an equivalent of 8 to 25 total units of intramuscular onabotulinumtoxin A in 4 to 8 nonmicrodroplet or 8 to 20 microdroplet injection points. Injection points should be placed higher on the forehead to avoid eyebrow ptosis. Intracutaneous injections, especially near the eyebrow, can be used to achieve superficial distribution of toxin to the frontalis muscle with lower dose per unit volume of muscle to prevent

eyebrow ptosis. Selection of precise BTX-A injection points is determined by assessing frontalis muscle activity and brow movement, taking care to avoid reducing frontalis activity in areas where activity is required to keep the brows elevated and shapely. While in most cases one row of injections is adequate, more than one row may be required in individuals with tall foreheads or dynamic rhytides that extend to the frontal hairline. The lateral extent of injections is determined by the frontalis muscle width and the desire to avoid overly peaked brows (Figs. 75-5 and 75-6).

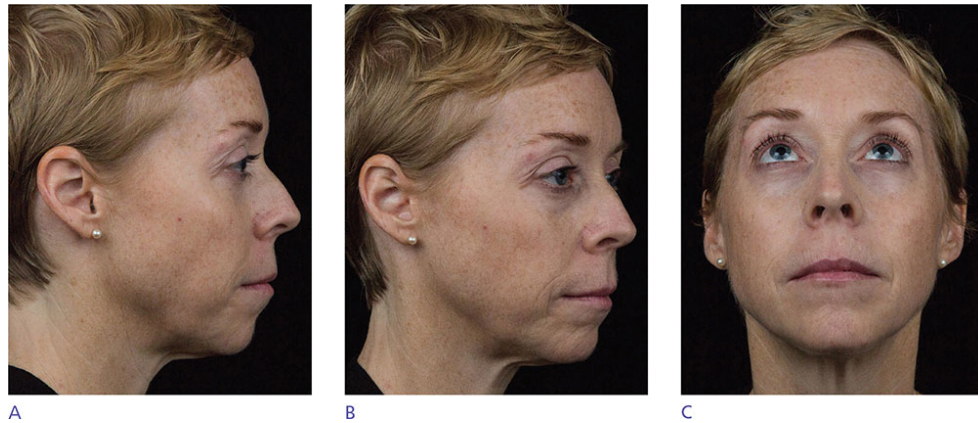


Figure 75-5. Preprocedure photographs.



Figure 75-6. After treatment with botulinum toxin in the forehead, glabella, nasalis (bunny lines), lateral canthal rhytides, and perioral rhytides and fillers in the temples, cheeks, marionette lines, and chin.

Precautions, pearls, and pitfalls

BTX-A injections should be placed higher on the forehead to minimize the risk of eyebrow and eyelid ptosis.

The risk of supraorbital nerve compression injury can be minimized by placing filler injections at least 1 cm lateral to the supraorbital foramen.

Eyebrows

Indications

Age and gender play a significant role in brow aesthetics. The ideal female brow sits slightly above the orbital rim, is more arched, peaking approximately two-thirds of the way along its length, and has a slightly higher tail than that of males. In contrast, the male brow tends to be positioned over the orbital rim and is straighter, without peaking or arching.³⁷ The main goal of brow treatment with fillers and botulinum toxin is primarily targeted toward brow reshaping and elevation.

Age-related eyebrow underprojection and ptosis is related to a number of factors including volume loss in the brow fat pad and bone attenuation, especially over the lateral brow. This is accentuated in part by the naturally occurring lack of brow elevators laterally and gradual diminution of cutaneous elasticity.³⁴⁻³⁶

Fillers

Periorbital skin is thin and delicate; hence, filler selection and injection requires the utmost attention. HA products such as Juvederm® Volift, Juvederm Ultra Plus, Restylane Lyft, Restylane Defyne, or Belotero® Intense can be used for deeper filler placements whereas Juvederm Volbella, Restylane Refyne, Restylane Fynesse, and Belotero Balance can be used for more superficial placement.

Drooping of the lateral brow can be corrected with deep filler placement in the subgaleal plane. This can be achieved through fanning with a blunt cannula or microdroplets using the serial puncture technique. Indirect elevation of the lateral brow can also be achieved by deeper placement of fillers with lifting capacities such as Juvederm Voluma or Restylane Lyft in the zygomaticotemporal suture line on the zygomatic arch. More superficial filler placement to correct deep static brow rhytides can be attained by using anterograde or retrograde linear threading injections. Caution is warranted in this zone because of the tenuous blood supply. Global brow lift can also be

achieved by deep placement of fillers on the orbital rim using a blunt cannula entering from a point over the lateral portion of the brow. Deep injections are not advised for the medial portion of the brow so as to avoid vessels and nerves that emanate from the supraorbital and supratrochlear notches.

Botulinum toxin

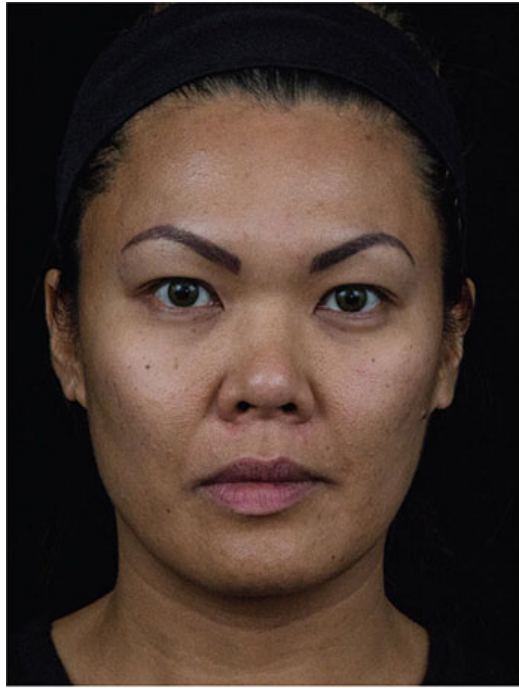
Brow shaping and lateral elevation can be achieved by reducing the effect of the brow depressor muscles. By slightly weakening the lateral orbital orbicularis oculi fibers that pull the brow downward in a purse string type of movement, the lateral brow can be elevated. Four to six units of BTX-A are subdermally administered laterally just superior to the brow over the point of maximal contraction of the orbital orbicularis oculi muscle. Asking the patients to close their eyes tightly can help to define the point of maximal orbicularis oculi contraction that is causing lateral brow depression. Subdermal placement of 1 to 2 units of BTX-A to the upper crow's feet can augment the lateral brow lift.

Medial brow elevation can be achieved by neuromodulating the corrugator supercilii and procerus muscles, which are the medial brow depressors.³⁴ Reshaping the brow area can be accomplished by strategic placement of BTX-A in the frontalis muscle. Lower injections on the frontalis will result in lower brow position, whereas higher injections have the opposite effect, elevating the brows. Utilizing a “V”- or “M”-shaped forehead injection pattern will typically create a more arched brow, while forehead injections carried out in a straight horizontal line typically yield a straighter brow.

A consensus group recommends two approaches with BTX-A³³ for brow elevation. The lateral brow can be elevated by injecting 1 to 2 intramuscular points (0.5–1 U of BTX-A) bilaterally to the orbicularis oculi at a point superior to the uppermost injection point for lateral canthal lines, typically at the brow hairline. Medial brow elevation is achieved by intramuscular injections (0.5–4 U of BTX-A) to the procerus, corrugator supercilii, depressor supercilii, and orbicularis oculi.

The global aesthetics consensus recommendations for HA fillers and BTX-A combination concludes that most panelists preferred a sequential approach to treat the upper face; initially with toxin, followed by filler. When both botulinum toxin and filler treatments are performed at the same visit,

fillers may be injected first, followed by toxin to avoid unnecessary tissue manipulation following toxin injection and permit more accurate filler implantation, as tissues are not distended by injected toxin (Figs. 75-7 and 75-8).



A



B

Figure 75-7. Preprocedure photographs.



Figure 75-8. After treatment with botulinum toxin in the masseters and fillers in the nasal bridge, nasal tip, zygomatic arch (upper lateral cheek), and chin.

Precautions, pearls, and pitfalls

Upper-eyelid skin excess can benefit from global brow lifting, especially in East Asian patients.

Blunt cannulas are safer than microdroplet injections for deeper filler placements.

Upper eyelids/infrabrow region

Indications

Upper-eyelid volume loss can present as multiple skin folds, as may be seen commonly in individuals of East Asian extraction and in others. Upper-medial-eyelid sulcus deformity, sometimes referred to as an “A-frame” deformity or infrabrow hollow, is also seen. Topical prostaglandin agonists have also been associated with reversible superior eyelid sulcus hollowing that improves when the medication is discontinued.^{38,39}

Fillers

The skin is very thin in this area and caution must be used to avoid clumping of product. Thus, HA products with hydrating properties and minimal lift capacity are desirable. Juvederm Volbella, Restylane Refyne, Restylane Fynesse, or Belotero Balance are a few examples of soft-tissue fillers that can be used in this area.

While blunt cannulas may be preferred in this area, some injectors use a serial microdroplet needle technique. When using a cannula, an entry point in the lateral aspect of the upper eyelid, 1 to 2 mm below the lateral edge of the brow, may be used. Filler placement should always be in the suborbicularis oculi plane. A 27- or 25-gauge, 1½-in cannula running superior to the primary fold and in the suborbicularis oculi plane of the superior sulcus with microaliquot placement of the desired filler should be used.^{40,41} The “walk the rim, feel the bone” needle injection technique is advocated by some injectors for superior sulcus filling. The injector palpates the orbital rim to avoid the supraorbital and supratrochlear notches. The needle is inserted until the tip touches the bony rim. Once bone is felt, the needle is withdrawn slightly so that a small amount of filler can be injected into the preperiosteal space just superficial to the bone. Multiple injections are given along the superior orbital rim, starting medially and moving laterally if necessary.

Precautions, pearls, and pitfalls

This is a challenging area that is best reserved for the most advanced injectors.

Beware the supratrochlear and supraorbital vessels when injecting the infrabrow region.

Exercise caution to avoid injection into the retro-orbital space.

Glabella

Indications

Dynamic rhytides over the glabella and medial eyebrow can be tackled with neuromodulators, followed by fillers if there is a need to address volume loss or residual static wrinkling. Patients with contraindications to

neuromodulators or those who choose not to avail themselves of BTX-A treatments might be managed with fillers alone, often achieving partial improvement of dynamic and static rhytides. Glabellar volume loss can be age- and race-related or secondary to long-term BTX-A use, which may result in regional muscle atrophy and secondary volume loss. Volume loss is best managed with soft HA fillers. The glabella is frequently treated in conjunction with the forehead region, as noted above.³¹

Filler

The glabellar region is the area most vulnerable to arterial occlusion and ensuing blindness with filler injection. Use of blunt cannulas and a thorough knowledge of injection anatomy may help to reduce this risk. Some injectors prefer to use needles, injecting superficially in the intradermal space to address superficial static rhytides and minimizing the risk of cannulating a vessel such as the supratrochlear artery. Threading or serial microdroplets are suggested placement techniques. Deep filler placement in the subgaleal plane using a cannula can help to volumize and lift the tissue, giving an aesthetically pleasing contour. Filler selection depends on the depth of product placement. HA products with lower viscosity and minimal lift capacity are desirable for superficial placement. Juvederm Volbella, Juvederm Ultra, Restylane Refyne, Restylane Fynesse, and Belotero Balance are a few examples. Deeper volumizing placements are best achieved with HA products such as Juvederm Volift, Juvederm Ultra Plus, Restylane Defyne, and Belotero Intense.

Deeper HA filler placement may be carried out using a blunt 25-gauge cannula. Midline or lateral forehead as well as lateral brow entry points may be used, depositing filler with a fanning, threading, or microaliquot technique while avoiding the supraorbital and supratrochlear notch. If sharp needle injections are desired, a 30-gauge or smaller needle is recommended. One approach with cannulas is to enter 2 cm above the orbital rim in the midline forehead, injecting subcutaneously to minimize the risk of traumatizing the neurovascular bundle located within the frontalis aponeurosis.

Superficial filler placement is best accomplished with serial sharp needle injections utilizing anterograde or retrograde threading or microaliquot deposits.

Botulinum toxin

Treatment of the glabellar region is best performed in the context of the entire glabellar–forehead complex in order to achieve optimal results.

Onabotulinumtoxin A was approved in 2002 by the FDA for the treatment of glabellar rhytides.⁴² A consensus group recommends an equivalent of 12 to 40 total units of intramuscular onabotulinumtoxin A. Doses as low as 8 units might be appropriate in some patients. Injection points can vary between three to seven sites targeting the procerus, corrugator supercilii, orbicularis oculi, and depressor supercilii muscles. Dosing and injection sites are best determined by assessing muscle bulk and activity, respectively. Thus, individuals with hypertrophic muscles will require higher dosing than those with less well-developed musculature. Clutching the procerus and supercilii muscles between the thumb and index finger of the nondominant hand helps to isolate these muscles, allowing for more accurate neuromodulator placement. Many injectors advocate injecting 1 cm above the orbital rim in order to prevent orbital diffusion leading to upper-eyelid ptosis.

A meta-analysis of seven clinical trials involving 1,474 participants found that a single treatment using 20 units of BTX-A is safe and effective for glabellar lines. Subgroup analysis confirmed BTX-A could improve static rhytides. The median duration of effect for dynamic wrinkles ranged from 92 to 125 days; a longer median duration of effect for static wrinkles was observed, ranging from 119 to 139 days.⁴³ Another meta-analysis of 16 trials involving 42,405 participants assessed BTX-A adverse effects. In 13 of these studies headaches, eyelid ptosis, and heavy eyelids were reported more commonly in the BTX-A treatment groups (Figs. 75-9 and 75-10).



Figure 75-9. Preprocedure photographs.



Figure 75-10. After treatment with botulinum toxin in the forehead, glabella, nasalis (bunny lines), lateral canthal rhytides, infraorbital area, and mentalis and fillers in the eyebrows, tear troughs (infraorbital), cheeks (upper and submalar), nose, marionette lines, chin, and angle of mandible.

Precautions, pearls, and pitfalls

Avoiding supratrochlear and supraorbital intravascular injections is critical in this region. Use of a cannula for deeper filler placement might be a safer approach.

With filler injections, the highest risk of blindness and changes is in the glabella (38.8%) followed by the nasal region (25.5%), nasolabial area (13.3%), and forehead (12.2%).⁴⁴

For patients being injected for the first time with BTX-A, starting with conservative dosing to prevent undesirable outcomes such as ptosis of the

eyelids and brows and eyebrow splaying is recommended. If necessary, a simple touch-up treatment may be done at 2 weeks.

Glabellar BTX-A injection patterns can be modified according to the five muscle contraction patterns; namely the “U,” “V,” “omega,” “converging arrows,” and “inverted omega” dynamic wrinkle patterns.⁴⁵ In Koreans, the patterns described include “U,” “11,” “X,” “ π (Pi),” and “I.”⁴⁶

Temples

Indications

Youthful temples are convex and form a continuous contour with the forehead and zygomatic arch without a sudden drop off in volume at the temporal suture line. Progressive temporal fossa concavity occurs with advancing age, emphasizing the bony outline of the lateral orbital rim.⁴⁷ Volume restoration and correction of temporal concavity may be achieved with soft-tissue fillers. In females, the goal of treatment is to make the temples appear flat and not convex, as might more commonly be done with male patients. Knowledge of local anatomy will help to minimize the risk of intravascular injection, especially of the superficial temporal artery, and avoid damage to the frontal branch of the facial nerve.³²

Fillers

The goal of filler treatments in the temples is to achieve a gentle straight or minimally concave contour, helping to position the lateral eyebrow more anteriorly, creating a continuous contour with the zygomatic arch. Some of the HAs that are used in the temples include Juvederm Voluma, Juvederm Volift, Juvederm Ultra Plus, Restylane Volyme, Restylane Defyne, and Belotero Intense. When utilizing a needle, slow bolus injections are commonly employed in the temples. Use of the tower technique with injections at different depths could potentially lead to intravascular injection as one withdraws the needle to inject more superficially.

The first injection point is placed at the intersection of two lines that are drawn 1 cm above the lateral orbital rim and 1 cm lateral to the temporal suture line. Further adjacent injection points may be used as clinically indicated.⁴⁷ Application of pressure near the temporal hairline will prevent

the flow of product into the scalp and will instead direct the product inferiorly to fill the temporal hollow. There are different schools of thought with respect to ideal injection depth. Some injectors promote deep injection such that the needle is deep to important neurovascular structures, while others suggest that superficial injections will minimize risks. One disadvantage of deep injections is that larger volumes may be required to achieve results comparable to those obtained with more superficial injections. However, the latter technique may lead to irregular surface contour, creating a “cobblestone” appearance due to superficial product placement.

Microcannulas may also be used in the temporal region. Entry at the posterior margin of the temporal fossa near the hairline²⁹ or at the zygomatic arch are two options for cannula insertion.

Precautions, pearls, and pitfalls

Precautions should be taken to avoid injury to the superficial temporal artery and the frontal branch of the facial nerve which are located close together in the subdermal fat.

Prior to injecting, palpate and avoid the temporal artery and slowly aspirate on the needle plunger to minimize the risk of an intravascular placement; keep in mind that a negative aspiration test does not guarantee nonintravascular placement.

Lateral canthal lines—crow’s feet

Indications

The lateral canthal region is a zone that commonly exhibits dynamic rhytides that eventually become evident in repose. Some volume loss may also be seen in the region. Both BTX-A and fillers can help to refine and rejuvenate that area.

Fillers

Three injection planes have been suggested, and these can be combined to achieve the best aesthetic results in the lateral canthal area. These include a superficial plane positioned immediately above the orbicularis oculi muscle,

a midlevel layer immediately below the orbicularis muscle, and a deep layer above the periosteum.⁴⁸ Filler selection will depend on the injection plane. HA products with lower viscosity and minimal lift capacity are desirable for superficial and midlevel placement to minimize the risk of the Tyndall effect and visible product accumulation. Juvederm Volbella, Juvederm Ultra, Restylane Defyne, Restylane Fynesse, and Belotero Balance are a few examples. Deeper volumizing injections are best achieved with HA products such as Juvederm Volift, Juvederm Ultra Plus, Restylane Defyne, and Belotero Intense.²⁷

Deeper injections may be achieved with linear threading or serial microaliquots using a blunt 27-gauge 1½-in cannula or sharp 30-gauge or smaller needle injections. The entry point for microcannulas can be located approximately 1 in below the lateral canthal commissure.²⁹ The risk of intravascular injection into the medial zygomaticotemporal vein may be lessened by using blunt microcannulas.⁴⁹ The lateral canthal tendon or lateral palpebral ligament is a fibrous structure attaching the lateral canthus and integrating it into a dense connective-tissue structure (Whitnall's tubercle) to bone. Stretching the lateral canthal tendon with deeper filler placement might lead to a taut lower eyelid with resultant globe overprojection.

Sharp needle microaliquots or cross-hatching injections may be desirable for more precise placement in the superficial and mid layers. Placement in both planes yields “sandwiching” of the orbicularis oculi muscle with resultant improvements in dynamic and static rhytides and skin texture.⁴⁸ Midlevel plane injections should be targeted toward the lateral suborbicularis oculi fat pad.⁵⁰

Botulinum toxin

Botulinum toxin is the cornerstone of treatment of lateral canthal rhytides. Dynamic rhytides are primarily caused by contraction of the lateral portion of the orbicularis oculi muscle. Zygomaticus muscle activity may also contribute to inferior lateral canthal rhytides. Four patterns have been described for crow's feet; full, upper, lower, and central fan (Fig. 75-11).^{51,52} The upper fan pattern was observed in only 10% of individuals studied.⁴⁸

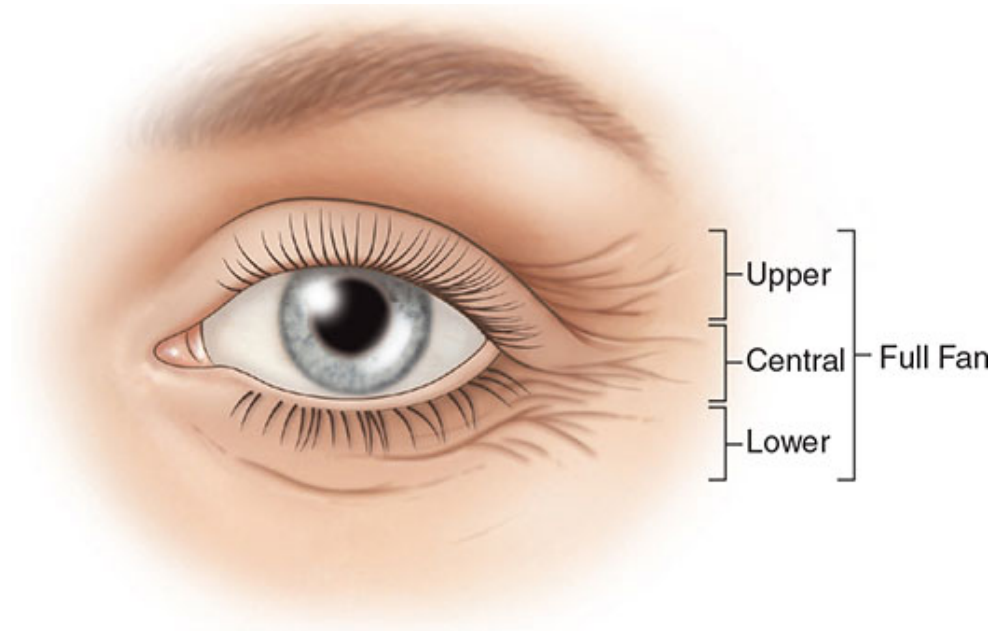


Figure 75-11. Four patterns have been described for crow's feet; full, upper, lower, and central fan.

Onabotulinumtoxin A was FDA-approved for crow's feet treatment in 2013.^{53,54} The global aesthetics consensus recommends an equivalent total of 6 to 25 units of intracutaneous onabotulinumtoxin A per side, with doses as low as 4 units in some cases. The number of injection points can vary between 1 and 5 per side. Injection of 1 to 4 units to the uppermost portion of the orbicularis oculi can also provide brow elevation. Reducing the dose per injection site to the inferior lateral orbicularis oculi was recommended to minimize spread of neuromodulator to the zygomaticus muscle, thus reducing the risk of smile asymmetry and a shelf-like appearance when smiling. The consensus panelists also recommended avoiding a second row of injections for rhytides extending toward the temporal hairline; however, this can be done for severely sun-damaged skin, or in patients who have undergone cosmetic surgery, such as face lifting with consequent extension of rhytides as far as the hairline.³³ In addition, the injector may want to inject oriented away from the eyes with needle bevel up and 1 cm lateral to the orbital rim to prevent diffusion of the product into the orbit.

Customized injection configurations according to the crow's feet pattern have been implemented in two phase 3 trials, suggesting it may be possible to administer 24 units in two different injection configurations into three sites per side.^{53,54} The first injection point is 1.5 to 2.0 cm temporal to the lateral

canthus, with the second and third injection points located 1.5 to 2 cm above and below the first injection point, respectively, at an approximate 30-degree angle medially for central, upper, and full crow's feet fan patterns. For the lower-fan crow's feet pattern, the first injection point is the same as described above. The second and third injection points are below the first one, made in an angled superoposterior to anteroinferior line. For the lowermost injection point, a line is drawn vertically from the lateral canthus and superior to the maxillary prominence. The anteroinferior injection is made just lateral to this line. The third injection is positioned at the midpoint along a line connecting the superoposterior and anteroinferior injection points.⁵⁵

Precautions, pearls, and pitfalls

Beware overtreatment of lateral canthal rhytides with botulinum toxin in order to avoid creating an unusual smile with a shelf-like appearance and overprojection of the cheeks anteriorly.

Sequential treatment over 2 separate days with BTX-A first and then HA was preferred by a global consensus group. Others feel that this approach is overly cautious and prefer to treat the same day.

MIDDLE THIRD OF THE FACE

Lower eyelids

Indications

For the lower eyelids, the tear trough is a predominant aesthetically displeasing feature that can often be corrected with HA tissue augmentation. Tear troughs are often caused by tissue thinning constrained by the orbitomalar ligament.⁵⁶ The tear troughs are frequently defined as the nasojugal fold;^{57–61} however, some prefer the term deepened nasojugal groove.⁶² Other lower-eyelid deformities that may benefit from soft-tissue augmentation include the palpebromalar groove, ectropion, and lid retraction.^{63,64} Tissue augmentation in either the lower eyelid or adjacent regions such as the medial cheek can improve not only the contour, but also

“crepey” skin, dermatochalasis, and static and dynamic rhytides.⁶⁵ A prospective study of 12 patients with tear troughs showed that treating the tear trough directly offers greater improvement when compared with treatment in the cheek alone.⁶⁶ BTX-A may improve dynamic and static rhytides in the lower-eyelid region, especially when combined with crow’s feet treatment.⁶⁷ BTX-A has been successfully used to treat lower-eyelid senile entropion, blepharospasm,^{69,70} epiblepharon, dry eyes and to widen the eye aperture, especially in Asian patients.⁷³

Fillers

HA products with lower viscosity and hydrating capacity are desirable in this region in order to minimize the risk of the Tyndall effect, edema, and product lumping. Juvederm Volbella, Restylane Refyne, Restylane Fynesse, and Belotero Balance are a few examples. Supraperiosteal placement was recommended for the nasojugal groove. In addition, lower-eyelid supraperiosteal and subcutaneous contouring can be performed, especially for tear troughs related to aging.^{27,48} Subcutaneous placement may also be used to address rhytides and skin-quality-related changes.⁴⁸ The risk of edema and Tyndall effect is thought to be higher with superficial product placement.

Serial microaliquots or linear threading with blunt 27 or 25 1½-in gauge cannulas or sharp 30 or smaller needle injections can be used for supraperiosteal placements to restore volume loss in the tear troughs/nasojugal folds, or the palpebromalar groove. The entry point for microcannulas can be located approximately 1 in below either the medial or lateral canthal commissures.²⁹ Supraperiosteal filler placement should be done inferior to the orbital rim below the level of the orbicularis oculi muscle.

Sharp needle injections with retrograde threading, microaliquots, or cross-hatching might be more appropriate for subcutaneous placements to treat lower-eyelid static rhytides. Sandwiching the orbicularis oculi as described in the lateral canthus region can be performed to achieve better aesthetic outcomes for both dynamic/static rhytides and skin texture.⁴⁸

Botulinum toxin

Dynamic infraorbital rhytides are primarily caused by orbicularis oculi muscle fiber activity. The global aesthetics consensus recommends an equivalent total of 0.5 to 2 units per side of intracutaneous onabotulinumtoxin A placed at one to three injection points in microdroplets to target the orbicularis oculi. In order to widen the eyes, 0.5 to 1 units per side of intracutaneous onabotulinumtoxin A placed in the midpupillary line will help to lower the inferior ciliary margin.³³ Same-session and sequential BTX-A and HA treatments are both acceptable options when treating the lower eyelid.²⁷

Precautions, pearls, and pitfalls

A history of lower-eyelid blepharoplasty should prompt the injector to exercise caution when treating the lower eyelids.

In order to minimize the risk of intravascular filler injections, slow injection and pulling back on the plunger are advised. The close proximity to the infraorbital foramen and vascular anastomoses with the retrobulbar blood vessels including the retinal artery and vein make this a high risk zone.

Gently massaging HA implants for more even distribution of the injected material is encouraged. A cotton tip applicator is helpful in this delicate region.

High-viscosity HA and nonbiodegradable agents should not be injected in the tear trough area.⁶¹

When injecting fillers in the tear trough, undercorrection is advocated, as the hygroscopic nature of HA fillers combined with neocollagenesis makes this area prone to edema, bulging, and the Tyndall effect.^{60,74}

Cheeks

Indications

The cheeks are bounded by the zygomatic arch and inferior orbital rim superiorly, the nose and nasolabial fold medially, the preauricular sulcus and the anterior border of the masseter muscle posteriorly, and the jawline inferiorly. Each cheek can be further subdivided into the upper medial cheek, upper lateral cheek (with the zygoma and malar prominence), and submalar cheek.

Aging leads to gradual maxillary bone resorption, anchoring ligament laxity, and adipose tissue atrophy, all of which lead to the development of concavities and tissue redundancy accentuated by gravitational effects. This in turn contributes to downturning of the angle of the mouth and accentuated jowls. Fillers are helpful in restoring volume loss and lifting the face. It is generally accepted that facial rejuvenation is best started in the midface, especially when the patient's budget is limited, as it has beneficial effects extending to untreated neighboring aesthetic units.⁷⁵ A tent-like effect from filler placement under the superficial musculoaponeurotic system (SMAS) on the zygoma yields lifting forces on the oral commissure, jowls, and nasolabial folds. Filling the upper medial cheek and infraorbital area elevates the upper lip elevators leading to indirect enhancement of nasolabial folds and marionette lines.

Cheek augmentation has been found to improve facial wrinkles and enhance the perception of attractiveness.⁷⁶

HA products with volumizing and lift capacity such as Juvederm Voluma, Juvederm Ultra Plus, Restylane Volyme, Belotero Volume, and Restylane Lyft are examples of suitable products. Calcium hydroxylapatite and PLLA have been also used. A single-blind controlled trial of 235 subjects demonstrated Juvederm Voluma as an effective filler for restoring midface volume with an acceptable safety profile and high patient satisfaction even with repeat treatments.⁷⁸ Juvederm Voluma was FDA-approved in 2013 as the first filler for age-related midface volume loss. PLLA was FDA-approved in 2009 as diluted suspension. Injection of PLLA is either by fanning through cannulas or longer needles with a series of approximately three treatments repeated every 6 weeks to achieve long-lasting volumizing effects.⁷⁹ CaHA was FDA-approved as a soft-tissue filler in 2006 with perceived longevity of results.^{80–83}

Zygoma and lateral cheek

Fillers

Juvederm Voluma had a duration of 19 months when used for the zygomaticomalar cheeks.⁷⁷ Product placement is aimed toward the preperiosteal fat and prezygomatic space just above the body of the zygoma

for volumizing; treatment of the malar eminence helps with facial lifting and conveying a youthful appearance; and fillers over the zygomaticotemporal suture line cause facial lifting through a tent-like effect on the SMAS. Small boluses and towering placements using sharp 30 or smaller needle injections are more precise but are associated with higher risk of bruising and intravascular injections. Cannulas are commonly used for midface product placement. Various cannula insertion points have been described. Surek et al. advocate three insertion points to allow volumization.⁸⁴ The first insertion point is positioned 1.5 cm inferolateral to the lateral canthus to create a lateral midface viaduct to approach the preperiosteal fat, prezygomatic space, lateral SOOF, and infraorbital fat compartment. An injector can use blunt or sharp cannulas to place small boluses or fanning threads within the same areas injected with the sharp needle. This can be achieved with a 25 1½-in gauge blunt cannula through the insertion point described, gliding it through deeper planes for filler deposition. Knowledge of the facial fat pads is essential for successful filler placement (Fig. 75-12).

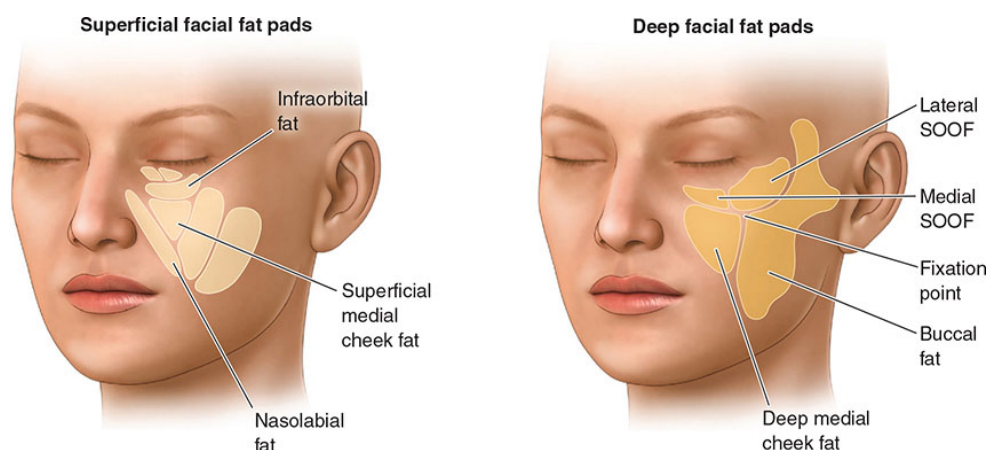
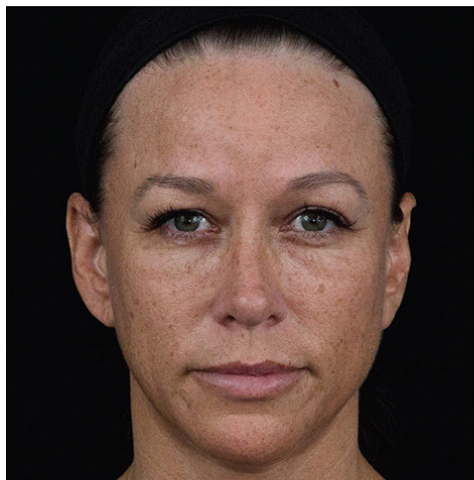


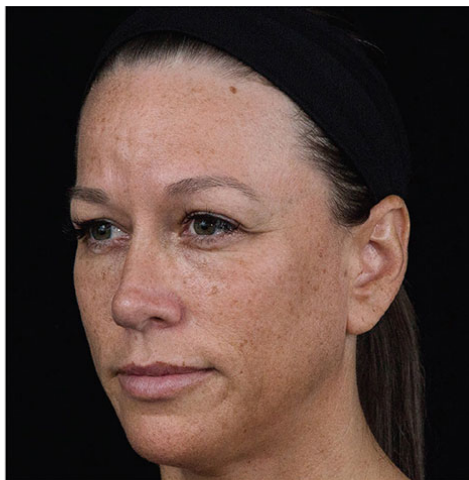
Figure 75-12. Knowledge of the facial fat pads is essential for successful filler placement.

Botulinum toxin

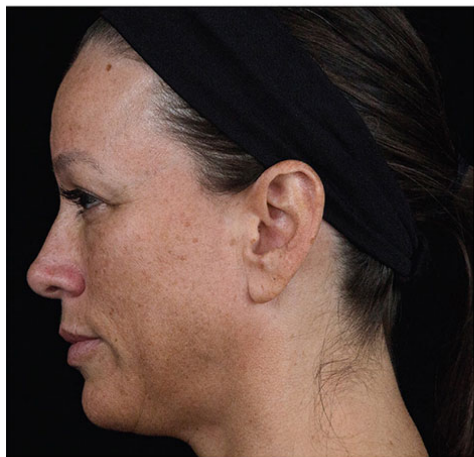
BTX-A may be suitable for treating hyperdynamic “accordion” cheek lines with 1 to 6 units of intracutaneous BTX-A to each side.²⁷ This can be achieved by one to two injection points over the mid-to-lateral malar eminence (Figs. 75-13 and 75-14).⁸⁵



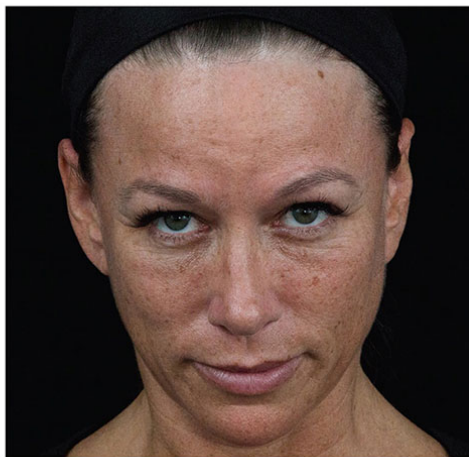
A



B



C



D

Figure 75-13. Preprocedure photographs.



Figure 75-14. After treatment with fillers in the upper medial cheeks, marionette lines, and zygomatic arch (upper lateral cheek).

Upper medial (anterior) cheek

Fillers

Juvederm Voluma correction lasted 24 months for the anteromedial cheeks.⁷⁷ Product placement should be aimed toward the premaxillary fat just above the body of the maxillary bone, deep middle fat pad, and inferior orbicularis fat pads. Small bolus placements using sharp 30 gauge or smaller needle injections are more precise but associated with higher risk of bruising and trauma to the infraorbital neurovascular bundle. Cannulas have been used for

midface product placement. Two of the three insertion points described by Surek et al. may be used to approach the anterior cheek. Port placement within a point created by the intersection of a horizontal line drawn from the nasal ala and intersecting with the nasojugal groove provide access to the middle superficial fat compartment. The other insertion point is located 1.5 cm inferolateral to the alar base in the nasolabial fold allowing access to the medial cheek fat compartment.⁸⁴ The injector can use blunt cannulas for small boluses or fanning threads within the premaxillary fat, deep middle fat pad, and inferior orbicularis fat pads. Alternatively, a portal of entry approximately 3 cm lateral and 1 cm superior to the oral commissure can be used. Cannulas can be 22 or 25 gauge and 1½ or 2 in long.²⁹ For more precise cannula product placements in the deep middle fat pad, it is often helpful to pinch the medial cheek to lift the superficial middle fat pad, allowing better access to the deep middle fat pad.

Precautions, pearls, and pitfalls

The infraorbital neurovascular bundle is a danger zone located on a line connecting the lateral palpebral commissure to the nasal ala. The closest mean distance between the infraorbital foramen and the infraorbital margin was measured as 8.8 ± 1.0 mm.⁸⁶

Submalar cheek

Fillers

Juvederm Voluma correction lasted 15 months for submalar cheeks.⁷⁷ Product placement should be aimed toward the deep subcutaneous fat ideally in the intermediate buccal fat pad (Fig. 75-12). Small bolus placements through cross-hatching or fanning can be accomplished using a sharp 30 gauge or smaller needle or blunt cannula. The same entry points described for the upper medial cheek can be used to approach the submalar cheek.⁸⁴ HA filler injections in a fanning pattern using a cannula in the subcutaneous space may be used to create structure and support for the submalar region so as to improve the gaunt appearance that may be seen with age and in individuals who perform extensive aerobic exercise. The end result is a softer silhouette with improved contour and less rhytid formation with animation.

Precautions, pearls, and pitfalls

Deeper filler placement is less effective in the submalar area due to the lack of bony support. Injectors should aim for cross-hatching strut work or a fanning pattern to establish tissue support.¹²

The Nose

Indications

Reversible nonsurgical rhinoplasty can be achieved with fillers to correct nasal radix, dorsum, supratip, tip, sidewall, and nasolabial angle deformities. Injectable rhinoplasty can also serve to provide a preview of results before proceeding to surgical rhinoplasty. In addition, the nose plays a major part in achieving forward projection of the facial “T zone” (i.e., forehead, nose, cheeks, and chin) that forms the basis for the panfacial approach in Asian faces.⁸⁷ BTX-A can be used to correct bunny lines, nasal flares, and in conjunction with fillers may achieve nasal tip elevation.

Fillers

Fillers with high viscosity are preferable. HA products such as Juvederm Voluma, Restylane Volyme, Belotero Volume, and Restylane Lyft are examples of products. CaHA is preferred by other injectors.⁸⁸ Unlike HA fillers, CaHA is not reversible, something which is less than ideal in this zone which is at high risk for vascular events.

Product placement should be aimed in the supraperiosteal/supraperichondrial planes. Injections in the nasal tip is an exception and should be subdermal with less viscous products such as Juvederm Volbella, Juvederm Ultra, Restylane Refyne, Restylane Fynesse, and Belotero Balance. A 30-gauge needle or smaller can be used, though blunt cannulas (1½ or 2 in, 27 gauge) are highly recommended to reduce the risk of vascular complications. Entry points are ideally placed distant from the desired injection site, usually from a lateral entry or at the nasal tip; however, an entry point at the nasal tip can provide access to the entire nasal septum and columella up to the nasal spine of the maxillary bone. Fillers can be placed in microaliquots (0.1 mL or less), usually proximal to distal

through serial needle punctures or a blunt cannula.⁸⁸ Injecting fillers above the nasal spine of the maxilla can help to correct downturned nasal tip deformities. Submucosal injections along the concave side of the curved anterior septum can also help to straighten the septum, correcting canted nasal tips caused by anterior septal deviation.⁸⁹

Botulinum toxin

The global aesthetics consensus recommends the following: (1) Bunny lines or nasal oblique lines are treated by targeting the nasalis and levator labii superioris alaeque nasi and depressor nasi septi as needed. Two to 4 units of intramuscular BTX-A to two or three injection sites are recommended. Up to five BTX-A units per injection site on each side of the nasal sidewall and rhinion area may be used. (2) Nasal flare is treated by targeting the dilator nasalis (alar portion of nasalis). The medial portion of levator labii superioris alaeque nasi may also be considered. One to two units of intramuscular BTX-A to two injection sites in the mid nasal ala are suggested. (3) Nasal tip elevation is achieved by targeting the depressor septi nasi. Two to six units of intramuscular BTX-A injected at the nasocolumellar junction in combination with fillers as described previously helps accomplish the desired result.

Precautions, pearls, and pitfalls

Extra care should be taken for nasal dorsum fillers. Aspiration first followed by very slow injection of microaliquots while observing tissue perfusion is critical to minimize the risk intravascular injection and blindness that is associated with filler treatments in this region.⁴⁴

Mold the filler and assess the nose meticulously to prevent nasal widening or nasal disfigurement.

The risk of vascular compromise increases with prior nasal surgery or intervention due to altered collateral blood supply.

The nasal tip should be corrected before the supratip area.

Preauricular and earlobe region

Indication

Volumizing the lateral face provides cutaneous support and tightening, which, when done in adequate quantity, may help to manage more medial facial wrinkling and laxity by providing a lateral pull effect. Dermal remodeling and increased epidermal layers have been demonstrated with HA injections in both the preauricular and nasolabial regions.⁹⁰ Restoring earlobe volume can also be achieved with HA injections, helping to restore ear-piercing hole elongation.⁹¹ In addition, a volumized earlobe helps to minimize rhytides and provides better support for earrings.

Fillers

HA fillers with high or medium viscosity are reasonable options. Filler placement should be aimed toward the superficial subcutaneous compartment of the lateral cheek fat pad (Fig. 75-12). A 30-gauge or smaller needle may be used. Blunt cannulas (1½ or 2 in, 25 gauge) are also recommended. Some common entry points for cannulas include just anterior to the tragus, the anterior border of the masseter on a line drawn from the tragus to the nasal ala, and just above the angle of the mandible and anterior to the earlobe. Filler can be injected with fanning or cross-hatching techniques. Earlobe volume can also be enhanced with 30-gauge needle injections with similar HA products used for the preauricular area. This can be done by holding the earlobe between the thumb and index finger of the nondominant hand for stability and injecting around the ear-piercing hole.⁹¹

Precautions, pearls, and pitfalls

Filler placement in the superficial subcutaneous lateral cheek fat pad compartment avoids injury to the more deeply located facial nerve, superficial temporal artery/vein, transverse artery/vein, and auriculotemporal nerve.

The superficial temporal artery and vein and auriculotemporal nerve are situated lateral to zygomatic process, placing them more superficial on this zone. Injectors should pay close attention when approaching the zygomatic process by palpating for vessels and preinjection aspiration.

LOWER THIRD

Perioral and lip augmentation

Indications

Aging results in progressive generalized perioral sagging, lip deflation, anterior mandible rotation in males, posteroinferior mandibular rotation in females, downturning of the corners of the mouth, and maxillary retrusion resulting in posterior upper lip and nasolabial fold positioning.⁹² Moreover, aging causes philtral elongation and flattening, decrease in lip height, and increase in intercommissural distance.⁹³ The perioral region is a highly dynamic area that is optimally treated with HA and BTX-A to reduce HA degradation by attenuating muscle contraction. A clinical trial of 90 female patients showed BTX-A and 24-mg/mL cohesive HA are effective and safe treatments either alone or in combination to rejuvenate the lower face with superiority demonstrated for combination therapy compared to either on its own.⁹⁴

The injector should keep in mind normal proportions and anatomy when correcting the lip and perioral area. The philtral columns are located just inside the peaks of Cupid's bow.⁸⁹ In addition, Cupid's bow is in the center of the two lower lip tubercles. The ideal lip length is such that the red vermillion body show is found between two vertical lines drawn down from the medial iris border or, in individuals with greater lower facial width, the medial pupil. The ideal ratio between the upper and lower lip vermillion body show is 1:1.618 (Phi) for Caucasian white patients and closer to 1:1 for all other races.⁸⁹ The red vermillion lip height should be more prominent medially with tapering and minimal projection in the lateral third of the upper and lower lips. The ideal youthful feminine lower lip should be fuller, but the upper lip should project more on profile by 1 to 2 mm.⁸⁹ Medial one-third shadowing inferior to the lower lip is typical due to mild lip eversion caused by the two tubercles. Age-related volume loss in the perioral region causes shadowing to extend beyond the medial third of the lower lip.

Augmentation of the vermillion and cutaneous lips can ameliorate volume loss due to bony and soft-tissue loss. Correction should also center on restoring the natural curves of the tubercle, cupid's bow peaks, and philtral crests. Smoker's lines can be treated conservatively with BTX.

Fillers

Soft and malleable fillers are recommended in order to maintain natural contours and movements. HA safety and effectiveness have been demonstrated in double-blind clinical trials for Juvéderm Ultra XC, small-gel particle HA (Restylane),^{96–98} and 24-mg/mL cohesive HA.⁹⁴ Juvederm Volbella was noninferior to Restylane-L at 3 months in a clinical trial of 280 subjects.⁹⁹

Injections are performed slowly with either blunt cannulas (1½ in, 27 or 25 gauge) or needle injections (30 gauge or smaller). A clinical study showed less bruising, ecchymosis, pain, and faster recovery with blunt cannula when compared to needle injections.¹⁰⁰

The cutaneous lip is approached differently from the vermilion lip. Filler is best placed in the subcutaneous layer and above the orbicularis oris muscle to volumize the cutaneous lip (through threading, cross-hatching, or fanning); in the subdermal layer to correct the philtral crests and trace perioral rhytides (through threading or microaliquots); and in the submucosal layer for the vermilion mucosal lip (through microaliquots). This helps to avoid intravascular injection in the superior labial artery, which runs between the orbicularis oris muscle layer and the mucosa, and inferior orbicularis oris muscle running between the orbicularis oris muscle and the lip depressors.¹⁰¹

Techniques for cutaneous lip needle injections can include threading, fanning, and cross-hatching. Anterograde threading can theoretically reduce injection complications in that filler can delicately dissect tissue in front of the sharp needle. Blunt cannulas, through fanning or threading, can place fillers through an entry point placed approximately 2 cm lateral to the oral commissure. The vermilion mucosal lip can be approached through blunt cannula microaliquots using the same entry points or points placed on the vermilion body just medial to the lateral commissures; however, intramucosal or cutaneous lip white roll serial puncture needle injections might provide more precision in filler placement.

A global consensus opinion on the combined use of HA and BTX-A suggested superficial Vycross, Hylacross, or dilution–reconstitution of Hylacross HA for perioral rhytides, and submucosal implantation of superficial Vycross or Hylacross for the lips. In addition, same-session and

sequential treatment were both considered viable options for combination treatment of the lips and perioral region, jawline, and neck.²⁷

Botulinum toxin

The global aesthetics consensus recommends an equivalent total of 1 to 5 units of intradermal onabotulinumtoxin A injected over two to five injection sites per side split between the upper and lower lips with 0.5 to 1 unit per injection point.

Precautions, pearls, and pitfalls

Application of topical anesthetic is helpful in alleviating injection-associated lip pain and is better tolerated and easier to perform than injectable anesthetic.¹⁰²

Lower-face-filler treatments are associated with the highest risk of bruising. Consider use of cannulas to minimize this risk.

Perioral BTX-A may be complicated by lip weakness, numbness, dysphagia, lip dryness, lip fullness, and swelling. The associated adverse events resolved in 21 days in 87% of 60 participants in a randomized clinical trial.¹⁰³ To minimize these risks, the conservative dosing may be used, especially in individuals with perioral soft-tissue volume loss.

Nasolabial region

Indications

Although often considered the standard area for many trials leading to FDA approval, direct treatment to this area has diminished over the years in favor of approaches that address the root cause of nasolabial folds, such as treatment of the adjacent upper medial/lateral cheeks and preauricular area. Nasolabial folds are not immune to age-related volume loss as may be seen with deepening of the nasolabial crest. An indirect approach may be utilized with complete treatment by directly addressing asymmetry and superficial rhytides.

A meta-analysis of 18 randomized clinical trials ($n = 2,521$) and seven nonrandomized clinical trials ($n = 346$) showed an improvement in the mean

Wrinkle Severity Rating Scale by 1.21 at 6 months post treatment. The Juvederm family achieved the best efficacy; however, in a subgroup analysis, the incidence of adverse events was significantly higher than with other HA products.¹⁰⁵ Another meta-analysis of four randomized clinical trials ($n = 331$) showed equivalence between CaHA and HA in hematoma and nodule formation.¹⁰⁶ Subsequent trials published after the meta-analyses demonstrated HA efficacy^{107–114} in the nasolabial folds. Other fillers studied in clinical trials include PMMA,^{115–117} PLLA,^{110,118–122} cross-linked dextran,^{117,123} and polycaprolactone.^{124,125}

Fillers

Direct nasolabial crease correction can be achieved with soft-tissue filler injections. It is a matter of debate as to whether to start superiorly or inferiorly. In general, complete effacement is not desirable, especially in the superior part of the nasolabial crease as it tends to flatten the face, making it appear unnatural. Three injection planes may be utilized based on the treatment goal. Supraperiosteal slow bolus or towering placements on the pyriform fossa helps to correct superior nasolabial volume loss and provide nasal tip elevation. Injection in the nasolabial fat pad can address tissue augmentation needed to treat volume loss. Filler placement in the nasolabial fat pad should be aimed at improving the inferior two-thirds of the nasolabial groove. Retrograde threading, fanning, or microaliquots can be used for filler placement in the nasolabial fat pad. The third injection plane is subdermal, when the goal is to address superficial nasolabial rhytides through microaliquots, fanning, threading, or cross-hatching techniques. Juvederm Volbella, Juvederm Ultra, Restylane Refyne, Restylane Fynesse, or Belotero Balance are a few examples that can be used in the subdermal plane. More dense fillers such as Juvederm Volift, Juvederm Ultra Plus, Restylane Defyne, and Belotero Intense are typically used for the nasolabial fat pad. More volumizing fillers with lifting properties such as Juvederm Voluma, Restylane Volyme, and Belotero Volume are preferably used in the supraperiosteal plane.

Injections are performed slowly and cautiously with 27- to 30-gauge needles for tissue augmentation in all three described planes. Fanning and threading with blunt cannulas (1½ or 2 in, 27 or 25 gauge) with an entry point inferomedial to the nasolabial fold are preferably used for filling the

nasolabial fat pad due the proximity of the blood vessels embedded in the adjacent deeper muscular planes. The nasolabial midface viaduct point can also be used as an entry point for blunt cannulas.⁸⁴

Botulinum toxin

The global aesthetics consensus recommends an equivalent total of 0.5 to 2 units of intramuscular onabotulinumtoxin A to 1 or 2 injection points per side to address excessive gingival show (gummy smile). Injection points are usually placed in the nasolabial triangle medial to the nasolabial groove and lateral to the nasal ala.

Precautions, pearls, and pitfalls

The nasolabial fold is a high-risk area for vascular occlusion. Inject small volumes slowly, while observing the skin for tissue perfusion.

Filler placements are preferably performed medial to the nasolabial groove with vertical rather than upward angling to avoid intravascular injection.¹² The use of blunt cannulas can reduce this risk.

In many cases, treatment of the cheeks prior to the nasolabial folds with fillers is preferable.

It is not uncommon to see nasolabial folds in youth. Thus, it is best to avoid completely effacing them.

Oral commissure and melomental folds (marionette lines)

Indications

Marionette lines and the concavity along the labiomental line commonly develop as a feature of aging. The etiology stems from a number of factors including volume loss in the supporting structures such as the cheeks and mandible. Correction and effacement is desirable so long as it doesn't masculinize the female face or create unusual fullness in the region. Indirect correction can be achieved with tissue augmentation at the angle of the mandible, preauricular area, and cheeks. Direct melomental rhytid correction can be accomplished with subdermal and subcutaneous filler placements.¹²⁶

A downturned mouth is another aging feature that can be addressed with BTX-A in the depressor anguli oris (DAO) and fillers to lift the corners of the mouth.¹²⁷

Fillers

Direct correction of the melomental crease can be achieved using a few approaches. By starting just medial to the lower part of the melomental crease, one can shorten the length of the crease, reduce the appearance of volume loss in this region, and improve the mandibular contour. Moving more superiorly helps to create a smooth transition as one moves from the lower medial cheek to the melomental region. In addition, downturned mouth angles can benefit from filler injections inferomedial to the oral commissures as well as BTX-A injections to the DAO.¹²⁸ It is helpful to consider the length of the mental crease when treating this area. Aim to ensure that the length of the mental crease is no more than half the length of the lips. By treating concavity in the melomental region, one can achieve this goal. As in the case of the nasolabial fold, three injection planes may be utilized for the melomental region. Supraperiosteal towering placement along the mandible can efface deep melomental folds. Subcutaneous injections are used for volume loss along the melomental fold and adjacent prejowl through fanning, threading, or microaliquot techniques. Subdermal microaliquots, fanning, threading, or cross-hatching techniques can be used for more superficial rhytides. Filler selection is similar to the nasolabial fold. Blunt cannulas (1½ or 2 in, 27 or 25 gauge) may be utilized with an entry point along the mandible, in the prejowl region. This access point permits treatment of the entire melomental region while also permitting access to the area lateral to the melomental fold if necessary. Blunt cannulas are best suited for subcutaneous and subdermal plane placements with fanning and threading techniques to correct volume loss and superficial rhytides, respectively. Rhytid correction of nasolabial, marionette, oral commissures, and upper and lower perioral rhytides was assessed in an open label study of 20 patients. The study evaluated small-gel-particle HA (Restylane) and large-gel-particle HA (Restylane Lyft). Both were found to be safe and effective for perioral wrinkles and correction of folds. Adverse events in decreasing order of occurrence were bruising, tenderness, swelling, redness, headache, and discomfort. Bruising was more common in the nasolabial crease and

marionette fold areas. Adverse events resolved within an average of 4 days.¹²⁹

Botulinum toxin

A global consensus paper for BTX-A treatment recommended an equivalent total of 2 to 4 units of intramuscular onabotulinumtoxin A to one or two injection points per side to the DAO muscle to attenuate the downward pull of the DAO muscle on the oral commissures. Of this group, 68% favored same-session treatments with BTX-A and fillers.²⁷ A split-face clinical trial of 20 patients revealed no difference between 10 units abobotulinumtoxin A versus 4 units onabotulinumtoxin A in treating the DAO muscle.¹³⁰

Precautions, pearls, and pitfalls

Beware the use of products that don't integrate well with tissue in this region so as to avoid the appearance of lumps at rest or with animation.

Combined cross-linked HA and onabotulinumtoxin A therapy in the melomental region may offer better overall cosmetic results with longer duration of aesthetic improvement than either treatment on its own.¹²⁸

Chin

Indications

The chin area contributes to both male and female attractiveness¹³¹ and is one of the most prominent elements of the lower third of the face.¹³² When looking at this area, the injector should perform a comprehensive facial assessment both at rest and with animation, with particular focus on mentalis muscle activity, the chin's soft tissue and bony support, and the chin's three-dimensional axes (anteroposterior, superoinferior, and transverse axes). Other facial areas to be evaluated in addition to the chin include the perioral region, lips, nose, and teeth.¹³² Those with microgenia and micrognathia/retrognathia may benefit from anteroposterior and superoinferior dimension corrections with volumizing fillers to the mental area. Excessive chin protrusion (mandibular prognathism) can indirectly benefit from augmenting the upper lip and anterior nasal spine to balance the

nose/upper lip and bring them forward. Anteroposterior chin augmentation indirectly helps minimize the appearance of maxillary prognathism and bulbar nasal appearances. Superoinferior axis prolongation can aid in retaining facial asymmetry in isolated microgenia and achieving more triangular feminine appearances with central chin augmentation superoinferiorly. Moreover, BTX-A to the mentalis can aid in elongating the chin area, attenuating the labiomental crease, and softening the *peau d'orange* appearance often seen with mentalis contraction. Transverse axis enhancement gives a more squared masculine appearance and should be approached with caution in females. Patients considering permanent chin implants might find that temporary filler injections can provide a useful preview of results that might be obtained with surgical implants.

Fillers

Juvederm Voluma, Restylane Volyme, Restylane Defyne, Restylane Lyft, Belotero Volume, and CaHA can be used because of their volumizing and lifting properties. Bolus and towering techniques may be used to preferentially expand any or all of the chin's three dimensions while maintaining the labiomental sulcus. Needles of 27- to 30-gauge size may be used for precise filler placements. Supraperiosteal towering or subcutaneous boluses to two points approximately 1 cm lateral to the midline and midway between the labiomental crease and mental border can provide anteroposterior axis augmentation. Subcutaneous or supraperiosteal towering injections in the midline approximately 1 cm inferior to the most anterior mental border can enhance the superoinferior chin axis giving the face a more elongated and triangular feminine appearance. Augmentation of the transverse axis can be achieved similar to the superoinferior injection technique; however, the injection points are placed at the lateral borders of the chin. A cannula technique to selectively augment the chin in the desired plane may be used as well. The entry point or points are typically located lateral to the chin in the prejowl region. Because of the fibrous nature of tissue in this region and strong mentalis activity, this can be an uncomfortable area to treat. It is also more common to experience posttreatment discomfort in this area because of edema.

Botulinum toxin

A total of 2 to 6 units of BTX-A may be injected in the mentalis muscle administered over one to four injection points. A global aesthetics consensus group recommended an equivalent total of 2 to 3 units of intramuscular onabotulinumtoxin A delivered over one to four injection points per side to the mentalis muscle to attenuate upward chin pull and reduce labiomental dynamic rhytides and *peau d'orange* appearance.

Precautions, pearls, and pitfalls

Patients and injectors tend to often overlook the chin area; however, this area when approached provides subtle yet impressive changes especially in restoring masculine features in a male face and an elongated triangular chin for the female face.

A more homogeneous chin augmentation appearance is achieved with the use of blunt cannulas.

When injecting BTX-A, injection medial to the lateral border of the mentalis will help to prevent depressor labii inferioris weakness and resultant lower lip asymmetry.

Jawline and masseters

Indications

Jowls are a telltale sign of aging that can be exacerbated by the appearance of volume loss in the pre- and postjowl sulci. Restoring volume loss can aid in creating a more defined and linear jawline. Indirect jowl improvement may be attained with fillers in the postjowl/mandibular angle and preauricular areas. Patients can benefit from the “Nefertiti lift” using BTX-A to contour the jawline.¹³³ Masseter hypertrophy can be ameliorated by BTX-A to attenuate lower facial rectangular appearances and attain a more triangular feminine facial appearance. A Cochrane review in 2013 could not identify any clinical trials assessing intramasseteric BTX-A¹³⁴; however, clinical trials were subsequently published.¹³⁵ A 24-week double-blind randomized split-face trial of 20 women showed the efficacy of both rimabotulinumtoxin B and onabotulinumtoxin A in treating masseter hypertrophy. Rimabotulinumtoxin B at a dose ratio of 70:1 to onabotulinumtoxin A had a shorter duration of action than onabotulinumtoxin

A.¹³⁵ It is prudent not to reduce masseter bulk if there are signs of jowls, as doing so may lead to jowl accentuation.

Fillers

Fillers such as Juvederm Voluma, Restylane Volyme, Restylane Defyne, Belotero Volume, and CaHA¹³⁶ can be used along the jawline.¹³⁷ Consensus recommendations were developed for jawline CaHA use.¹³⁷ Subcutaneous and preperiosteal planes are best suited for filler placement in the prejowls, jowls, and postjowls/mandibular angles. Linear threading or microaliquot techniques can be used with either 25- to 30-gauge needle injections or 1½ to 2 in 27- or 25-gauge blunt cannulas. Injections in the pre and postjowls should be positioned under the mandibular rim. The entry point for cannulas may be just above the mandibular angle and below the ear lobule.²⁹ Alternatively, for more medial correction, the cannula may be inserted along the mandibular rim in the prejowl sulcus.

Botulinum toxin

The global aesthetics consensus for BTX-A treatment recommends an equivalent total of 5 to 15 units of intramuscular onabotulinumtoxin A to one to five injection points per side to the masseter muscle. The typical total dose of onabotulinumtoxin A is 15 to 40 units to each side. The “Nefertiti lift” can be achieved by injecting 2 to 3 units of BTX-A into five points uniformly distributed along the mandibular border of each side.¹³³

Precautions, pearls, and pitfalls

Careful attention is required when injecting fillers along the mandible as facial vessels and the marginal mandibular nerve cross the mandible just medial to the masseter muscle. Use of a cannula may reduce the risk of intravascular injection.

Avoid overcorrection of the jawline so as to prevent masculinization of the female face.

COMPLICATIONS

Injectors are advised to acquire a thorough knowledge of injection anatomy as well as BTX-A and filler complications and their management. Injectable adverse events can generally be classified as early and late complications. BTX-A adverse events are mainly limited to bruising and undesirable muscle weakness leading to undesirable facial expressions or facial asymmetry. Early filler complications include pain, erythema, bleeding, bruising, swelling, overcorrection, misplacement, infection, allergic reactions, tissue ischemia, necrosis, and blindness. Late complications include granuloma formation, nodules, filler migration, dyspigmentation, infection, and biofilm formation.^{138,139} For a detailed discussion of treatments associated with neuromodulators and fillers, see [Chapters 57](#) and [58](#), respectively.

The global aesthetics consensus¹³⁹ recommends the following toolkit for managing HA filler complications: hyaluronidase, oral and intralesional steroids, empiric antibiotics (minocycline, ciprofloxacin, or clarithromycin), antiviral agents, topical nitroglycerin (1%), antihistamines, aspirin 325 mg orally, warm compresses, bacterial culture kit, and phone numbers of prearranged referrals (e.g., ophthalmologists, hyperbaric oxygen).

CONCLUSIONS

The past several years have seen a paradigm shift to viewing facial aging and the development of rhytides as a three-dimensional process. Thus rather than simply filling in facial creases, injectors now focus on volumizing the face to indirectly address the root cause of wrinkle formation. Judicious combinations of neuromodulators and fillers provide patients with a minimally invasive—though not risk free—approach to wrinkle reduction that may ultimately lead to an aesthetically pleasing outcome.

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CHAPTER 76 Approaches to Dyspigmentation

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SUMMARY

- The classification of dyschromias is based on the location of melanin in the skin. This can be seen clinically by variation in color of the lesion, Wood's lamp examination, as well as histopathologically.

- The therapeutic plan primarily consists of identification and removal of causative as well as triggering factors and stringent photoprotection coupled with the use of depigmenting agents.

Beginner Pearls



- Sun avoidance is the most important part of the treatment of hypermelanoses, both for current improvement and future prevention of recurrence.
- Hydroquinone (HQ) is a mainstay topical depigmenting agent in the treatment of dyschromias, particularly melasma and postinflammatory hyperpigmentation.
- Multiple chemical peels have efficacy for dyspigmentation, including glycolic acid, Jessner's, and TCA peels.

Expert Pearls



- Laser and light options include IPL, QS Nd:YAG, QS ruby, and QS alexandrite.
- The patient should be adequately primed for around 2 to 4 weeks pre-peel with topical skin lightening agents such as HQ, GA and kojic acid, or tretinoin, coupled with regular sunscreens.

Don't Forget!



- Regardless of intervention used, fundamental medical management, including religious photoprotection, is absolutely essential and even the most complex intervention will fail if the patient does not comply with the fundamentals.
- Melasma patterns include centropacial, malar, and mandibular patterns.

Pitfalls and Cautions



- Combination peels should be used cautiously in darker-skinned patients because of the risk of PIH and scarring. Patients with long-term use of HQ increase their risk for exogenous ochronosis.

Patient Education Points



- Rigorous sun protective behavior should be instilled in patients, including the use of broad spectrum (ideally physical blocking) sunscreens with a minimum sun protection factor of 30, along with sun protective hats and clothing.
- Patients should understand that multiple treatments may be required and that their degree of improvement with each treatment session may be unpredictable.
- Always err on the side of underestimating the improvement that will be seen.

CHAPTER 76 Approaches to Dyspigmentation

INTRODUCTION

A large number of conditions may manifest with increased pigmentation of the skin. While some of them may be predominantly limited to the face, extra-facial dyspigmentation may be a major source of concern as well. These cause significant cosmetic disfigurement and therefore negatively impact the quality of life (QOL) of affected patients. This vast group of complex diagnostic and therapeutic problems includes well-defined clinical entities as well as those which have defied classification.

CLASSIFICATION OF DYSCROMIAS

The classification of dyschromias is based on the location of melanin in the skin. This can be seen clinically by variation in color of the lesion, Wood's lamp examination, as well as histopathologically.

Brown hypermelanosis

Lesions appear brown-black in color and there is accentuation of pigmentation on Wood's lamp examination. The excess melanin is present in epidermis, mainly in basal and suprabasal layers. The pigmentation can be melanotic (increased production of melanin by normal number of melanocytes) or melanocytic (increased number of melanocytes in the basal layer).

Blue hypermelanosis

The excess melanin is present in the dermis, which lends a blue color to the lesion (Tyndall effect), and the pigmentation is not accentuated on Wood's lamp examination. The dermal pigmentation is due to pigmentary incontinence (PI) caused by basal cell layer damage, and the melanin may be present either free in the dermis or within melanophages. Other causes include ectopic dermal melanocytes and exogenous pigment deposition.

Mixed hypermelanosis is due to increased pigment present in both epidermis and dermis.

MELASMA

Melasma is a common pigmentary disorder. The nomenclature is Greek from the word *melas* (black), as it manifests clinically as symmetric hyperpigmented macules on photo-exposed areas. It is more common in darker skin types (Fitzpatrick skin types IV–VI), especially in people of Asian and Hispanic origin who live in areas with high sun exposure.¹ It typically affects women of reproductive age, with prevalence in men being much lower.^{1,2}

Etiology

Although several factors have been implicated in the etiology of melasma, it remains incompletely understood. The main causative factors include ultraviolet (UV) radiation, hormonal factors (pregnancy and oral contraceptive pills), and genetic predisposition. Other possible contributors include cosmetics, photosensitizing drugs, thyroid disease, ovarian tumors, and stressful events.¹ It is hypothesized that in a genetically predisposed person, development of melasma depends on the interaction between environmental and hormonal influences. Melasma has been reported in identical twins, and many patients have an affected family member.³ Some drugs such as phenytoin, griseofulvin, NSAIDs, finasteride, and imatinib have been implicated to cause melasma-like pigmentation.^{1,4,5}

Pathogenesis

UV radiation causes cell membrane damage along with peroxidation of its lipids leading to the generation of reactive oxygen species (ROS), stimulating melanogenesis. Infrared and visible light also play a role in the development of melasma. Circulating estrogen binds to estrogen receptors present on melanocytes leading to melanogenesis and subsequent pigmentation.⁶ The number of melanocytes within involved areas may be normal or increased. Melanosomes within affected melanocytes are increased in size.

Clinical features

Melasma presents clinically with symmetrical hyperpigmented macules present predominantly on sun-exposed areas. The face is the most commonly affected site; rarely, there may be involvement of other areas such as the neck or forearms.

Melasma Patterns

- Centrifacial: Most common, pigmentation on cheeks, forehead, upper lip, nose, and chin
- Malar: Less common, pigmentation present only on cheeks and nose
- Mandibular: Least common, pigmentation on ramus of the mandible

Melasma Types

- Epidermal: Pigment is brown and margins of the lesions are well defined and geographical
- Dermal: Pigment is gray-brown and margins of the lesions are poorly defined
- Mixed: Melanin is present both in epidermis and dermis
- Indeterminate: Difficult to classify melasma in darkskinned individuals

POSTINFLAMMATORY HYPERPIGMENTATION

Postinflammatory hyperpigmentation (PIH) is an acquired dyschromia that usually occurs after either acute or chronic skin inflammation or injury. PIH can arise in all skin types, but more frequently affects patients with darker skin (Fitzpatrick skin types IV–VI).⁷

Etiology

Various types of inflammatory conditions or cutaneous injuries lead to pigmentary changes including both hyper- and hypopigmentation. However, certain diseases show a greater tendency toward development of hyperpigmentation such as dermatophytoses, viral exanthems, insect bite reaction, contact dermatitis, lichen planus, drug hypersensitivity reactions, and acne vulgaris.⁸

Pathogenesis

The excess production of melanin as a result of inflammation leads to epidermal PIH. An irregular dispersion of pigment as the result of an inflammatory process causes dermal PIH. Inflammation damages basal keratinocytes, leading to release of melanin into the dermis followed by phagocytosis and formation of melanophages in the upper dermis. The rise in melanocyte activity is stimulated by inflammatory mediators such as prostacyclins, cytokines, and chemokines as well as ROS released during the inflammatory process.⁷

Clinical manifestations

PIH clinically presents as hyperpigmented macules in the same distribution as the initial trigger. The color of the lesion is determined by the location of the excess pigment, and the intensity of the pigmentation correlates with the higher skin phototypes. Further, PIH tends to worsen with UV exposure or with persistent or recurrent inflammation.

Other causes of dyschromias include a wide range of disorders like Riehl melanosis, lichen planus pigmentosus, erythema dyschromicum perstans, facial pigmentary demarcation lines, and Poikiloderma of Civatte. The etiology in most of these entities is unknown, but factors such as exposure to UV radiation, chemicals, allergens, and photodynamic substances in cosmetics have been implicated.⁸ Apart from these acquired dermatoses of dyspigmentation, certain disorders like Nevus of Ota are also well-known causes. A brief description of the etiology, clinical features, and the histopathology of some of the other important causes of dyspigmentation is detailed in [Table 76-1](#).

MANAGEMENT

Table 76-1. Etiology, Clinical Features, and Histopathology of Common Hypermelanoses

Hypermelanoses	Aetiology	Clinical Features	Histopathology
Riehl melanosis (Pigmented contact dermatitis)	Allergens like cosmetic, occupational, textile, musk ambrette, chromium hydroxide, aniline and azo dyes, hair dyes, red kum-kum, and fragrances	Diffuse/reticular Brown-slate-gray pigmentation over areas of exposure, rarely satellite perifollicular pigmentation and scaly follicular hyperkeratosis May be preceded by signs of dermatitis-like mild erythema and pruritus	Basal cell degeneration, pigment incontinence, perivascular or band-like dermal infiltrate, dermal melanophages
Poikiloderma of Civatte	Sun exposure, photo-dynamic substances in cosmetics	Reddish-brown reticulate hyperpigmentation, telangiectasias and dermal atrophy over photo-exposed areas like face and neck, excluding submental areas under the chin	Telangiectasia, fibrosis, and melanophages in upper dermis with solar elastosis
Facial pigmentary demarcation lines (Futcher's or Voight's lines)	Genetic, hormonal	Types: A-G homogeneous pigmentation, bilateral symmetry	Increased pigmentation in basal layer and mild perivascular lymphocytic infiltrate in upper dermis
Nevus of Ota (nevus fusco-caeruleus ophthalmomaxillaris)	Genetic (incomplete embryonal migration of melanocytes from neural crest to epidermis)	Usually unilateral Speckled/coalescing brown to blue-colored macules distributed in area supplied by the ophthalmic and maxillary branches of the trigeminal nerve can also involve eye and hard palate	Elongated dermal melanocytes present in papillary to midreticular dermis
Erythema dyschromicum perstans (Ashy dermatosis of Ramirez)	Unknown. HLA-DR4 Exposure to ammonium nitrite, radiographic contrast media, intestinal whipworm infestation, cobalt allergy, and HIV infection	Asymptomatic, multiple, slate-gray macules of variable sizes Early lesions: erythematous hue and elevated erythematous border, gradually enlarging and coalescing, present over the face extending to neck, trunk, and limbs	Vacuolar basal cell degeneration with pigment incontinence, deep dermal melanophages, lymphohistiocytic infiltrate around vessels
Lichen planus pigmentosus	Unknown. Exposure to cosmetics, hair dyes, fragrances, mustard oil, etc.	Asymptomatic, diffuse, slate-gray macules present over exposed areas and flexures. Mucous membranes characteristically spared	Orthokeratotic atrophic epidermis and lichenoid lymphohistiocytic inflammation, prominent pigmentary incontinence and melanophages in superficial dermis
Periorbital melanosis	Genetic, dermal melanin deposition, postinflammatory hyperpigmentation, shadowing from lax skin, extension of pigmentary demarcation lines, etc.	Presence of variegated brown-black discoloration around the eyes	Dermal melanocytosis and melanin pigment in superficial dermal macrophages
Addison pigmentation	Due to primary adrenal insufficiency (autoimmune adrenalitis, tuberculosis, metastatic malignant disease, amyloidosis, and congenital adrenal hypoplasia)	Pigmentation most prominent on the light-exposed areas, flexures, palmo-plantar creases, friction-prone areas, normally pigmented sites (e.g., nipples and genitalia), and mucous membranes Minimal pigmentation is sudden onset Addison's disease	Epidermal melanotic hyperpigmentation
Exogenous ochronosis	Prolonged use of HQ	Present in the HQ-treated photo-exposed areas like cheeks, forehead, temporal, and periorbital areas	Banana-shaped bodies of yellow-brown color in dermis with giant cells and melanophage-rich granuloma
Acanthosis nigricans	Insulin resistance, genetic, obesity, drug-induced, autoimmune, paraneoplastic	Hyperpigmented, velvety plaques of body folds may also involve the face as well	Hyperkeratosis, papillomatosis, irregular acanthosis horn pseudocysts, dermal plasma cells, and lymphocytic infiltrate
Freckles (ephelides)	Familial, sun exposure	Brownish macules of size 2–4 mm over photo-exposed sites like face, upper back, dorsal forearms, and hands. Tend to increase in size and become darker in summers and reduce in size and become lighter in winters	Melanosomes are normal in number but larger in size and rod shaped
Lentigines	Familial, phototherapy, sun exposure	Brownish to black macules of varied sizes present all over the body. Darker in color and remain same in size and color throughout the year	The number of melanocytes is increased

The management of dyschromia entails a multimodal approach addressing multiple factors contributing to the development of the disease. Many of these

factors are not completely understood, adding an additional dimension of difficulty to the treatment of the various diseases. The therapeutic plan primarily consists of identification and removal of causative as well as triggering factors and stringent photoprotection coupled with the use of depigmenting agents. Apart from the aforementioned interventions, counseling forms an integral component of the management, whereby patients need to be informed about the natural history of disease, length of the treatment, and tendency to persist or recur. Furthermore, efforts should be made to understand the impact of the disease on the QOL of the patients and the treatment plan should also be aligned such as to provide maximum improvement. Additionally, use of cosmetic camouflage should be offered to patients during the treatment as well as an alternative for those who cannot use or tolerate therapy.

Sun avoidance is the most important part of the treatment of hypermelanoses, both for current improvement and future prevention of recurrence. Additionally, use of sunscreen has been documented to increase the efficacy of topical hydroquinone (HQ)-based treatments.^{9,10} Rigorous sun protective behavior should be instilled in the patients including the use of broad spectrum sunscreens (UVA and UVB) along with physical blocks (zinc oxide or titanium dioxide) with a minimum sun protection factor of 15, along with sun protective hats and clothing.

Pigment reduction can be brought about by both medical and physical modes of treatment. As there is no universally effective treatment and efficacy of existing agents is variable, responses can vary and relapses are frequent. The treatment options include multiple topical and oral depigmenting agents, chemical peels, and physical modalities such as dermabrasion and lasers. Among the medical treatments, HQ and triple-combination creams (HQ + retinoic acid [RA] + corticosteroid [CS]) remain the gold standard, while other options include dual combinations (HQ + RA, CS + RA, HQ + CS), kojic acid, azelaic acid, arbutin, ascorbic acid, tranexamic acid, mequinol, rucinol, lignin peroxidase, orchid extracts, licorice extract, and various other botanicals which are in different stages of development. Other treatment options include chemical peels like glycolic acid (GA), mandelic acid, lactic acid, Jessner's and retinoid peels as well as lasers like Q-switched neodymium-doped yttrium aluminum garnet (QS Nd:YAG) laser (1,064, 532 nm), Q-switched ruby (694 nm), and Q-switched alexandrite (755 nm).

Topical agents

Hydroquinone

HQ is a mainstay topical depigmenting agent in the treatment of dyschromias, particularly melasma and PIH. Its mechanism of melanogenesis disruption is brought about by the inhibition of the conversion of tyrosine to L-3,4-dihydroxyphenylalanine (L-DOPA) and its eventual conversion into melanin.¹¹ HQ is available in 2% concentration as an over-the-counter medication in the United States. Increased concentrations are available through prescription, though generally this is capped at 4% in the United States. It is applied twice daily to affected areas, and known side effects (SE) include irritant and allergic contact dermatitis, nail discoloration, hypopigmentation of surrounding normal skin, and exogenous ochronosis.¹² There is increased risk of each of these adverse reactions with increased concentrations of HQ.¹³ Exogenous ochronosis clinically shows gray-brown hyperpigmentation with associated pinpoint hyperchromic papules and banana-shaped fibers along the papillary dermis on histopathology.¹⁴ Patients with long-term use of HQ increase their risk for exogenous ochronosis. If exogenous ochronosis is suspected, application of HQ should be stopped.¹⁵ Rodent studies have suggested oral HQ as a possible carcinogen. However, there has been no association found between HQ and cancer in humans.¹⁶

Options for Management of Melasma

Medical Treatments

HQ

Triple-combination creams (HQ + retinoic acid [RA] + corticosteroid [CS])

Dual-combination creams (HQ + RA, CS + RA, HQ + CS)

Kojic acid

Azelaic acid

Alternative Treatments

Arbutin

Ascorbic acid

Tranexamic acid
Mequinol
Rucinol
Lignin peroxidase
Orchid extracts
Licorice extract

Chemical Peels

Glycolic acid
Mandelic acid
Lactic acid
Jessner's
Retinoid peels

Lasers and Light

IPL
QS Nd:YAG laser (1,064, 532 nm)
Q-switched ruby (694 nm)
Q-switched alexandrite (755 nm)

Azelaic acid

Azelaic acid is a dicarboxylic acid isolate from the organism *Pityriasis ovale*. It acts through competitive inhibition of tyrosinase and by disrupting mitochondrial enzymes and DNA synthesis on hyperactive melanocytes.¹⁷ It has also been shown to have bacteriostatic effects on *Propionibacterium acnes*.¹⁸ The multiple mechanisms of action of Azelaic acid make it effective in a variety of hyperpigmentation disorders including acne vulgaris, rosacea, melasma, and PIH. It is available in a 20% cream and 15% gel or foam. Known common adverse reactions include erythema, burning, and pruritus. Of note, azelaic acid has not been found to be associated with exogenous ochronosis as seen in HQ use.

Cosmeceuticals

There are a variety of cosmeceuticals used in the treatment of hyperpigmentation disorders. Although other topical agents, such as HQ and retinoids, are the mainstay of treatment used in hyperpigmentation,

cosmeceuticals can be used as adjunct or alternative treatment options. Cosmeceuticals decrease pigmentation by the disruption of different steps along the melanocyte activation pathway or through exfoliation of keratinocytes containing melanosomes. Many cosmeceutical options are derived from natural sources such as botanicals. Among many others, a few examples of commonly used agents include ascorbic acid, kojic acid, arbutin, and licorice and soy extracts. Ascorbic acid is a naturally occurring antioxidant that interacts with copper ions on tyrosinase active sites and reduces oxidized dopaquinone. The botanicals kojic acid, arbutin, and licorice extracts inhibit tyrosinase. Soy extracts inhibit PAR-2 activation which inhibits keratinocyte phagocytosis of melanosomes, and thus melanosome transfer. While the mechanisms of action of many of these agents have been shown in vitro, more clinical studies are needed to better understand their efficacy in treating patients with hyperpigmentation disorders.^{19,20}

Rucinol

Rucinol is a derivative of resorcinol found in fir trees in Siberia. It works by inhibiting the activity of tyrosinase and tyrosinase-related protein-1. One randomized controlled trial showed Rucinol serum 0.3% to have efficacy in treating melasma as evidenced by significantly lower clinical pigmentation scores after 12 weeks.¹⁷ Liposome encapsulation has been shown to improve the stabilization and penetration of Rucinol.²¹

Methimazole

Methimazole is an emerging agent used for depigmentation. It is a peroxidase inhibitor that is a noncytotoxic inhibitor of melanin production. The first case report of topical 5% methimazole use in treating PIH in a patient showed a moderate improvement of the hyperpigmented areas following daily use for 6 weeks.²² Another report showed significant improvement of melasma in HQ-resistant melasma patients using the application of 5% methimazole cream once daily for 8 weeks.²³

Commercially available depigmenting agents

There is a wide array of commercially available depigmenting agents. Due to SE of mainstay approaches such as HQ, many skin-lightening agents have been used as alternative and adjunct therapy. While each agent has its own unique characteristics, many of them share the same mechanism of action, which is the inhibition of melanogenesis and resulting depigmentation. Some examples of commercially available depigmenting agents include vitamin E, grape seed extract, orchid extract, aloe vera extract, pycnogenol, and N-acetyl glucosamine.²⁴

Retinoid therapies

Topical retinoids are used in a variety of conditions including acne, solar lentigines, melasma, and PIH. Topical tretinoin can be used as a monotherapy or as part of a triple-combination therapy (fluocinolone acetonide 0.01%, HQ 4%, tretinoin 0.05%) to treat melasma. Tretinoin can be used in monotherapy by the mechanism of depigmentation through dispersion of keratinocyte pigment granules along with interference of pigment transfer and accelerated epidermal turnover.²⁵ One study showed significant clinical improvement of melasma using topical 0.1% tretinoin as a monotherapy.²⁶ As part of the triple-combination therapy, it also improves HQ penetration through the stratum corneum and protects it from oxidation.²⁷ Adverse reactions from topical retinoid therapy include pruritus, erythema, peeling, and burning.

Tranexamic acid

Tranexamic acid is a plasmin inhibitor.²⁸ It is used to slow and prevent excessive bleeding. It is also used in the treatment of melasma and PIH. One study demonstrated tranexamic acid's ability to reduce melanin synthesis in both cultured murine and human melanocytes in a highly inflammatory state. Tranexamic acid acts by decreasing tyrosinase protein expression, thus reducing inflammation-induced melanogenesis.^{29–31}

Combination therapy

Combination therapy consists of three agents, including HQ 4%, tretinoin 0.05%, and dexamethasone 0.01%. It is applied once daily to affected areas. Recent evidence shows fixed triple-combination therapy is superior to HQ

4% monotherapy in the treatment of moderate to severe melasma.³² Tretinoin helps with penetration and prevents oxidation of HQ. Dexamethasone reduces the risk of irritant dermatitis and may also reduce melanin production.³³ Combination therapy is also used in PIH, but more trials are needed to prove efficacy.

PROCEDURAL THERAPIES

The medical management of the dyschromias remains the most tried and tested approach and brings about decent improvement. However, in some cases where faster treatment is required or in those whom are resistant, various procedures can be used adjunctively to bring about an optimal response. Further, the combination of procedural treatments helps reduce the amount and dosages of topical agents, helping in minimizing their SE.

Chemical peels

Chemical peels form an important component of the therapeutic armamentarium against hypermelanoses (Figs. 76-1 to 76-5). Over the last decade, multiple studies have documented their efficacy in the management of dyschromias. Peels act by creating injury to a specific depth in the skin which then stimulates new epidermal growth and collagen induction, thus improving texture and appearance. These changes, coupled with exfoliation, lead to dispersion as well as even redistribution of melanin in skin, thus reducing the visible pigmentation. Among the superficial, medium, and deep peels, the specific peeling agents should be chosen based on the condition to be treated and the histologic level of pigment in skin (Table 76-2). The most commonly used peels are superficial and medium-depth peels, as the damage is confined to the epidermis and upper dermis. The deeper peels are not suitable for dyschromias in darker skin because of increased chance of pigmentary disturbances including postinflammatory dyspigmentation by the peels. Apart from the peeling agent, various other factors affect the depth of penetration of the peel and thus the results (Table 76-3). Other aspects, such as skin type, total area of involvement, safety issues, downtime, and patient compliance should also be taken into consideration to maximize results.



Figure 76-1. A 24-year-old adult female with diffuse slate-gray pigmentation over entire face (lichen planus pigmentosus) and localized brown-black-speckled pigmentation over nose (melasma).

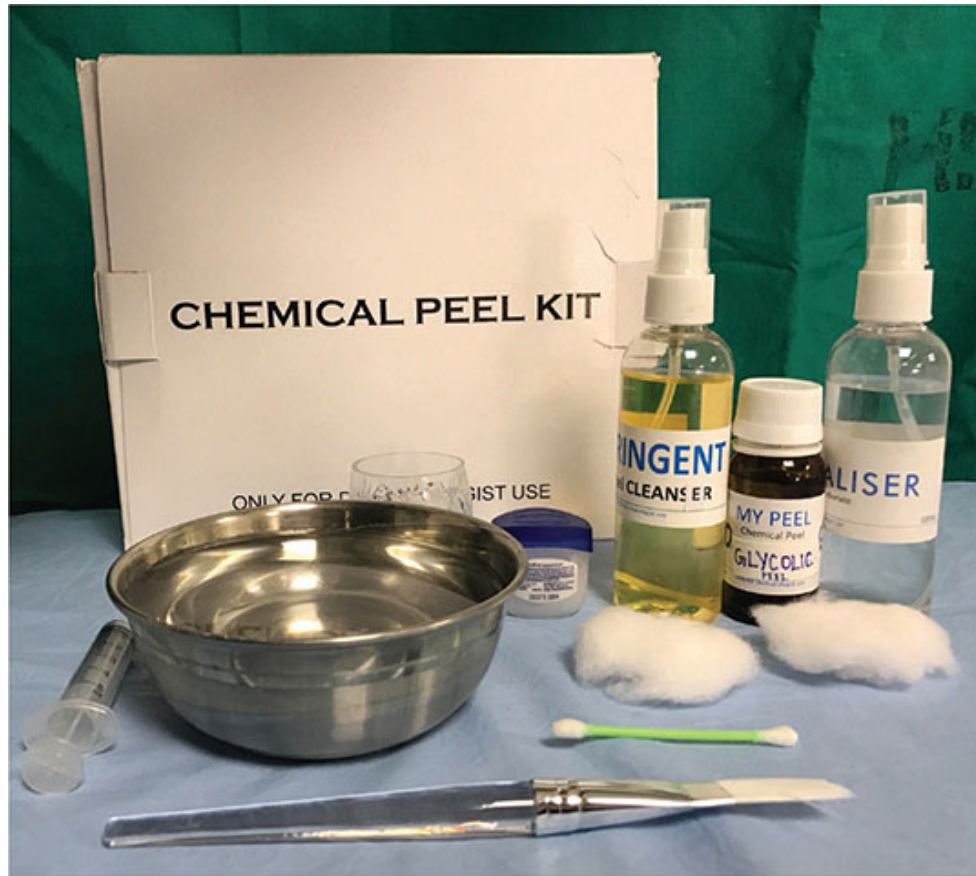


Figure 76-2. Equipment required for peel: The chemical peel along with pre-peel cleanser, post-peel neutralizer, glass peel cup, brush applicator, petrolatum jelly, cotton bud, eye pads, and bowl of water.



Figure 76-3. Patient preparation: The patient lies down with head elevated to 45 degrees, hair pulled back with a cap, eyes closed and covered with moist eye pads, skin is cleaned, and then degreased with acetone-based cleanser. Sensitive areas like the inner and outer canthus of the eyes, nasolabial folds, and angles of mouth are protected with petroleum jelly.



Figure 76-4. Peel application: The peeling agent is applied with a brush applicator on the entire face, beginning from the forehead proceeding to both cheeks, chin, nose, and malar area in that order with care taken to maintain uniform pressure and perform feathering strokes at the edges.



Figure 76-5. Neutralization: The glycolic acid peel is neutralized after the predetermined duration of time with 10% sodium bicarbonate solution and washed off with water. However, if erythema or epidermolysis occurs, the peel must be neutralized immediately, irrespective of the duration.

Table 76-2. Classification of Chemical Peels

Type of peel	Penetration Depth	Peel Agent	Indications
Very superficial	Stratum granulosum	GA 20–50% SA 20–30% TCA 10–15% Jessner's solution 1–3 coats	Melasma, solar lentigines, PIH
Superficial	Up to entire Epidermis	TCA 10–30% GA 70% Jessner's solution 4–10 coats	Solar lentigines, melasma, PIH
Medium-depth	Upper reticular Dermis	TCA 35–40% Phenol 88% Brody's combination Monheit's combination Coleman's combination	Melasma, lentigines, PIH, lichen planus pigmentosus
Deep	Midreticular dermis	Baker–Gordon peel (phenol 88% + tap water+ liquid soap + croton oil)	Dermal-type melasma, PIH

Table 76-3. Factors Affecting the Depth of Peel

■ Peeling agent
■ Concentration used
■ Number of coats applied
■ Technique of application
■ Pre-peel priming
■ Cleaning and degreasing before peel
■ Duration of contact
■ Anatomic location of peel
■ Alteration of skin surface

A wide range of peels are available with different mechanisms of actions, which can be modulated by altering the concentration of the agents. The most commonly used peels for hypermelanoses are GA, salicylic acid (SA), trichloroacetic acid (TCA), Jessner's peel, tretinoin peel, as well as newer peels such as lactic acid, mandelic acid, pyruvic acid, kojic acid, β -lipohydroxy acid, and ferulic peel. Combination peels can be used to increase the depth of penetration of the peel and its benefit without increasing its concentration, thus reducing the SE.

Glycolic acid

GA belongs to the family of α -hydroxy acids, which are naturally occurring compounds. GA is readily available in many preparations such as solution and gel base. It is used in varying concentrations ranging from 10% to 70%.

GA peels should be repeated once every 2 to 4 weeks for a minimum of four to six peels. GA must be neutralized with normal saline or sodium bicarbonate. It is the most commonly used peel for hypermelanosis including melasma and PIH and is safe and effective in all skin phototypes, although caution needs to be exercised in cases of any pre-existing cutaneous inflammation, where penetration could be deeper, resulting in unpredictable results and SE.³⁴

Trichloroacetic acid peel

TCA is a self-neutralizing crystalline inorganic compound used for superficial and medium-depth peels. Concentrations range from 10% to 65%, with higher concentrations leading to increased penetration. It is commonly used in the management of solar lentigines, freckles, melasma, PIH, and acanthosis nigricans.^{35,36} The results with TCA peel are good in most patients, although it can sometimes show unpredictable response and relapse, along with significant risk of local reactions such as dyschromias and scarring, especially in Fitzpatrick skin types IV to VI. However, when used cautiously in appropriate concentrations, the risk of complications is lower.

Salicylic acid peel

SA is a naturally occurring β -hydroxy acid derived from the bark of the willow tree. It is used at a concentration of 20% to 30% and applied at weekly to 2-weekly intervals for four to six sessions and has been found to be moderately effective in treatment of hypermelanoses including PIH and melasma.³⁷

Jessner's peel

Jessner's peel consists of three keratolytic agents with additional skin-lightening properties: 14 g each of SA and resorcinol and lactic acid (85%) in ethanol (95%). Apart from its prominent role in acne, it has been found to be useful in hypermelanoses as well, especially when used as a combination peel.

Combination peels

Combination peels such as Brody's combination (solid CO₂ + 35% TCA),³⁸ Monheit's combination (Jessner's + 35% TCA),³⁹ Coleman's combination (70% GA + 35% TCA),⁴⁰ and Jessner's solution with GA⁴¹ can be used to increase the depth of penetration of the peel and its benefit without increasing the concentration, thus reducing the SE. However, these should be used cautiously in darker-skinned patients because of the risk of PIH and scarring.

Newer peels

Various peels, including lactic acid,⁴² arginine, pyruvic acid,⁴³ mandelic acid⁴⁴ along with tretinoin peels,⁴⁵ and Obagi blue peel⁴⁶ have been used in treatment of hypermelanoses with encouraging results and a good safety profile. Another new chemical peel on the horizon is lipohydroxy acid (an SA derivative) which has good penetration throughout the epidermis due to increased lipophilicity and greater keratolytic effect.⁴⁷

Procedure and assessment

An adequate preprocedure assessment of the patient should be done prior to commencing with the peel sessions. This has been detailed in [Table 76-4](#) and ideally includes detailed history, and complete medical examination (general physical and cutaneous examination) along with photographs. The procedure should be explained to the patient and an informed consent obtained. A properly performed assessment helps the surgeon choose an appropriate candidate for the peel procedure, and allows the provider to identify the patients at risk for SE ([Table 76-5](#)). It is absolutely imperative to take a proper history of these points as well as look for them during examination because the peeling procedure could lead to unfortunate SE in such patients.

Table 76-4. Pre-Peel Assessment of the Patient

History	Examination	Investigations
■ General medical history ■ Degree of sun exposure ■ Occupation ■ History of herpes simplex ■ Keloidal tendency ■ Tendency for PIH ■ Current medications ■ Smoking ■ H/o systemic disease, particularly cardiac disease (phenol peels) ■ Isotretinoin treatment in the last 6 months (medium-depth and deep peels)	■ General physical and cutaneous examination including skin type ■ Degree of photoaging ■ Degree of sebaceous activity ■ Presence of PIH ■ Keloid or hypertrophic scar ■ Active Infection ■ Pre-existing inflammation ■ Depth of lesion	■ Skin biopsy should be done when indicated ■ Hemogram, urinalysis, liver and renal function tests, and electrocardiograph (phenol peels) ■ Informed consent after counselling ■ Photography

Table 76-5. Contraindications for a Peel

■ Active bacterial, viral, fungal, or herpetic infection
■ Open wounds
■ H/o drugs with photosensitizing potential
■ Underlying inflammatory dermatoses
■ Uncooperative patient
■ Patient with unrealistic expectations
■ For medium-depth and deep peels—history of abnormal scarring, keloids, and isotretinoin use in the last 6 months

The patient should be adequately primed for around 2 to 4 weeks pre-peel. Priming can be performed with topical skin-lightening agents such as HQ-, GA-, and kojic acid-based preparations or topical tretinoin, coupled with regular sunscreens. A postauricular test peel can be performed to rule out any allergic reactions or SE. After the peel has been completed, post-peel instructions should be explained to the patient and the importance of photoprotection and emollients should be stressed upon.

Complications

Superficial peels are generally safe and well tolerated with mild SE, but chances of adverse reactions are higher with medium-depth peels and maximal with the deep peels. The SE of peels may depend on factors such as peel agents, concentration, skin type, and concomitant medications. The complications and their management have been listed in [Table 76-6](#). The best way to prevent complications is to complete an appropriate pre-peel assessment, identify those at risk for adverse events, and choose a peel that balances efficacy with known SE profile.

Table 76-6. Prevention and Management of Complications of Chemical Peels

Complication	Prevention	Management
Immediate		
Skin irritation, itching, or burning	Avoid high peel concentrations, excess amounts, irregular pressure	Emollients, topical steroids
Erythema, edema	Stop photosensitizers, sun exposure	Topical steroids, photoprotection, sunscreens
Eye problems	Eye protection, petroleum jelly around eyes, careful peel application	Saline irrigation of eye, ophthalmology referral
Late		
Infection (bacterial /candidal/ herpetic)	Avoid rubbing, itching, scratching Prophylactic antiviral therapy (history of herpetic infection)	Topical or oral antibiotics/antifungals Oral antiviral therapy
Reaction to chemical agent: (acneiform eruption, allergic reaction, and cardiac toxicity)	Test peel and meticulous pre-peel assessment	Topical antibiotics, steroids, intralesional corticosteroids Cardiopulmonary monitoring in case of phenol peel
Abnormal wound healing (hypertrophic scar/keloid/delayed healing/milia)	Avoid itching or scratching Proper pre-peel assessment Early neutralization of peel if necessary	Occlusive dressing, intralesional steroids, surgical excision
Pigmentary alterations (hyperpigmentation/hypopigmentation/demarcation lines)	Proper pre-peel assessment Priming, photoprotection Feathering during peel application	Topical depigmenting agents/lasers

Intense pulsed light

The use of intense pulsed light (IPL) was first described in 1976 by Muhlbauer et al. for the treatment of telangiectasias.⁴⁸ It has since been shown to be effective in treating a variety of dyspigmentation disorders. Examples of its use include the treatment of melasma, acne vulgaris, rosacea, solar lentigines, and actinic keratosis.⁴⁹ It works by emitting a noncoherent, polychromatic light via a filtered flashlamp.⁵⁰ The light is placed at a set wavelength spectrum (500–1,300 nm) and pulse duration. First-generation IPL devices emit infrared light which commonly led to epithelial damage. Second-generation IPL devices filter out the infrared portion of the light, thus reducing the risk of SE.⁵¹ The mechanism of action of IPL involves absorption of light energy by melanin in keratinocytes and melanocytes. This is followed by the formation of microcrusts in these sites of epidermal injury with subsequent shedding off of the crusts leading to improvement of pigmentation.⁴⁹ A recent study demonstrated the effectiveness of IPL therapy in the treatment of melasma in Chinese patients. Results showed 77.5% of participants obtained 51% to 100% improvement with the mean melasma area and severity index scores decreasing from 15.2 to 4.5.⁵²

Q-switched neodymium-doped yttrium aluminum garnet (QS Nd:YAG) laser

QS Nd:YAG lasers are used to treat dyspigmentation due to their low potential for scarring. One of its advantages is its ability to penetrate deeply through the skin (up to 1 cm) in order to target melanosomes present in melanocytes, keratinocytes, and phagocytes. It works by inducing selective photothermolysis of melanosomes. This is accomplished through producing large temperature gradients between the melanosome and its surrounding structures causing fragmentation of the melanosome. In addition high-pressure acoustic waves produced by the laser lead to melanocyte death.⁵³ One study followed 50 patients receiving weekly QS Nd:YAG laser treatment for melasma over a 9-week period. Results showed a decrease in mean melanin index by 35.8%. However, the recurrence rate at 3 months was 64%.⁵⁴ Significant SE from recurrent QS Nd:YAG laser therapy include hypopigmentation, rebound hyperpigmentation, and melasma recurrence.⁵³

Pulsed-dye laser

Pulsed-dye laser (PDL) was the first laser developed to utilize selective photothermolysis to treat dyspigmentation. It uses specialized liquid dye suspension as the source of the laser beam. PDL was first used in the treatment of port-wine stain birthmarks and other vascular lesions, but has since shown efficacy in treating a broad range of dermatologic conditions.⁵⁵ For example, studies have shown PDL's effectiveness in treating acne scars.⁵⁶

Fractional lasers

Fractional photothermolysis (FP) creates an array of microscopic treatment zones via thermal injury to the skin. FP spares tissue surrounding each microscopic thermal wound. In comparison to selective photothermolysis, FP causes tissue damage in microscopic columns that extend into the dermis. The close proximity of uninjured tissue to the microscopic treatment zones allows for shorter migration paths of keratinocytes leading to faster healing. FP spares the stratum corneum, which acts as a natural barrier surrounding the wounds.⁵⁷ FP is effective in treating a wide range of conditions including acne scars, facial dyschromia, melasma, and granuloma annulare.⁵⁸

Numerous ablative and nonablative fractional lasers have been produced. Nonablative fractional lasers use focused midinfrared laser micro beams to create microthermal treatment zones. Nonablative fractional lasers generally require multiple treatments in order to produce results.⁵⁹ There is no downtime associated with nonablative fractional laser therapy. Ablative fractional lasers use carbon dioxide or erbium lasers to cause destruction in the columnar patterned microthermal treatment zones. Adverse events associated with fractional laser therapy include erythema, edema, and PIH.⁵⁹

CONCLUSIONS

Many therapeutic approaches are available for the treatment of dyspigmentation. While medical therapy may play a significant role, many patients are eager for an intervention that has a more rapid onset of action and with a less subtle clinical course. Thus, peels and laser and light sources play an important role in dyspigmentation management.^{60,61} Still, regardless of intervention used, fundamental medical management, including religious photoprotection, is absolutely essential, and even the most complex intervention will fail if the patient does not comply with the fundamentals.

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CHAPTER 77 Approaches to Erythema and Telangiectasias

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SUMMARY

- Erythema and telangiectasias are a common patient complaint.
- The mainstay of therapy is laser and IPL treatments; IPL confers the advantage of larger spot sizes, and thus more efficient treatments.
- Patients should always understand that multiple treatments will be needed, and maintenance therapy is generally required.

Beginner Tips



- Regardless of the device chosen, a slight amount of overlap of pulses is necessary to achieve uniform improvement of the treated area.
- KTP causes more swelling and bruising compared to PDL and IPL.
- PDL is safer than KTP in those with darker skin types given increased depth of penetration.
- Do not use IPL on those with tanned or sunburned skin.
- There should be approximately 10% overlap with IPL to avoid a “stamping” appearance following treatment.

Expert Tips



- Telangiectasias of the nose can be very treatment resistant; recurrence rates are quite high, necessitating maintenance treatments.
- In many patients, it can be difficult to permanently eliminate alar telangiectasias altogether; caution patients from the outset that maintenance treatments are often necessary.
- Another factor for the physician to consider when treating large areas is the wear and tear to the laser itself—larger areas consume more of the dye kit and cryogen.

Don't Forget!



- The neck and chest skin have a thinner epidermis and dermis compared to the face, so typically gentler settings should be used.
- It is important to become familiar with the device you choose to use. Devices of the same wavelength do not necessarily have interchangeable settings, and the time to development of erythema or purpura following a single pulse varies between devices. Also, service of the laser (such as replacement of a dye kit) may influence the performance and actual energy delivered.

Pitfalls and Cautions



- Do not pulse stack with a 1,064-nm laser, which increases the risk for scarring.
- 1,064 nm has the greatest risk for causing retinal damage because of its deep penetration, so caution should be exercised near the eye with appropriate shielding.
- Many laser experts avoid 1,064-nm laser treatments on the nasal ala due to an increased risk for depressed scarring.

CHAPTER 77 Approaches to Erythema and Telangiectasias

INTRODUCTION

Prominent erythema and telangiectasia of the face, neck, and chest are frequent complaints and reasons for presentation to the dermatology office. The most common etiologies of these signs are rosacea and photodamage, with less common reasons being alcoholism, medication use, connective tissue diseases, and genetic disorders, such as hereditary hemorrhagic telangiectasia. Sun exposure damages and weakens collagen and elastin, and cumulative exposure results in vascular ectasias and physical signs of erythema and telangiectasias.

UV photodamage is believed to contribute to the development of rosacea. Rosacea symptoms typically include frequent flushing associated with facial erythema, telangiectasias, papules, and pustules. Patients with CREST (calcinosis, Raynaud's phenomenon, esophageal dysmotility, sclerodactyly, and telangiectasia) often present with what are classically referred to as mat-like telangiectasias. These are most prominent on the face, neck, and hands (Figs. 77-1 and 77-2).



Figure 77-1. A 30-year-old female with a history of Raynaud's presented for treatment of telangiectasias. She was noted to have mat telangiectasias on the forehead.



Figure 77-2. The same patient was treated with one session of 1,064 nm, 90 J/cm², and 7 ms followed by the 590-nm IPL at 30 J/cm² with pulse width of 2.4 ms, 15-ms delay, and 5 ms with significant improvement. The patient receives periodic laser treatment to maintain clearance of the mat telangiectasias, and was diagnosed with CREST syndrome at age 40.

Connective tissue disease and other systemic illnesses may cause facial erythema and telangiectasias; patients with polycythemia vera have been referred in the past for laser treatments (Figs. 77-3 and 77-4). Medications that can cause erythema include niacin (rather than nicotinamide), calcium channel blockers, cyclosporine, rifampin, vasodilators such as nitroglycerin, and others. It is also important to keep in mind that topical and intralesional steroids can cause telangiectasias and erythema. Intrinsic aging of the skin causes collagen breakdown and visible telangiectasias. Lastly, repeated trauma to the face will also induce localized erythema, and ultimately vascular dilation. Telangiectasias frequently develop in and around surgical scars, particularly those that are under tension.



Figure 77-3. A 40-year-old male presented for treatment of redness of the face. Several years earlier, the patient had presented for the same complaint, and was noted to be diffusely erythematous and diaphoretic. He was referred to his primary care physician for workup of systemic illness, and was found to have polycythemia vera. The patient was started on aspirin 81 mg and phlebotomy. On reevaluation, the patient was much less red, but demonstrated prominent telangiectasias on the cheeks, nose, and chin and diffuse facial erythema.



Figure 77-4. Marked improvement in erythema after receiving three treatments using the Cutera Excel V (535 nm) with 10-mm spot, 8.6 J/cm², and 10 ms. The pulse count ranged from 153 to 160 pulses per session.

Currently, the most effective treatment of erythema and telangiectasias is by lasers and intense pulsed light (IPL); however, other therapies play a role as well. Patients with erythema and telangiectasias should be instructed on a gentle skin care routine of using lukewarm water, mild cleansers, and moisturizers. Prescription topical agents for erythematotelangiectatic rosacea include metronidazole gel, lotion and cream, azelaic acid foam and gel, and ivermectin cream. Although the former agents are more effective for papulopustular rosacea than erythema and flushing, topical agents may be included as adjunctive anti-inflammatory approaches for rosacea patients.

Brimonidine gel (Mirvaso, Galderma, Lausanne, Switzerland) is an α -2 adrenergic agonist which causes vasoconstriction and can be used for erythema of varying etiologies. When this agent was initially on the market there was much enthusiasm for its potential efficacy, though in clinical practice marked rebound erythema has occurred with cessation of use, even after 1 to 2 days of application; such rebound erythema may extend to areas beyond the area of direct application. Because of these side effects, the popularity of brimonidine has declined. Results of studies on topical

oxymetazoline are currently under review by the Food and Drug Administration.

Cosmeceuticals can be used to reduce erythema and telangiectasias.¹ Topical and oral nicotinamide, green tea, feverfew, and licorice root all have been shown to be possibly beneficial for erythema via varying anti-inflammatory mechanisms. Green tea has also been shown to possibly protect against ultraviolet B (UVB) damage.

Historically, electrocautery was used to treat telangiectasias. This has fallen out of favor given the damage to the epidermis when trying to reach underlying vessels, and the risk of resultant scarring. In addition, while the immediate response to cautery appears successful, recurrence is common.

LASERS AND LIGHT-BASED DEVICES

Background

Laser treatment of erythema and telangiectasias is based on the theory of selective photothermolysis: the chosen wavelength of light should correspond to the absorption peak of the target structure and the pulse duration should be equal to or less than the thermal relaxation time of the target structure. This principle dictates that selective destruction of the target takes place with minimal damage to surrounding structures.

For erythema and telangiectasias the target structure is usually oxyhemoglobin within the vessels, as this comprises the majority of total hemoglobin. To understand the best wavelengths to treat superficial red vessels, one must know that oxyhemoglobin's primary absorption peaks are in the blue–yellow–green portion of the visible light range (418, 545, and 577 nanometers [nm]); the lowest wavelength peak of 418 nm is strongly absorbed by melanin, however, and therefore should not be utilized for vascular lasers (Fig. 77-5). Even light with wavelengths at the peak of 542 nm will have too much absorption by melanin and therefore fail to be photoselective for hemoglobin, resulting in probable epidermal damage, unless cooling is used to protect the epidermis.

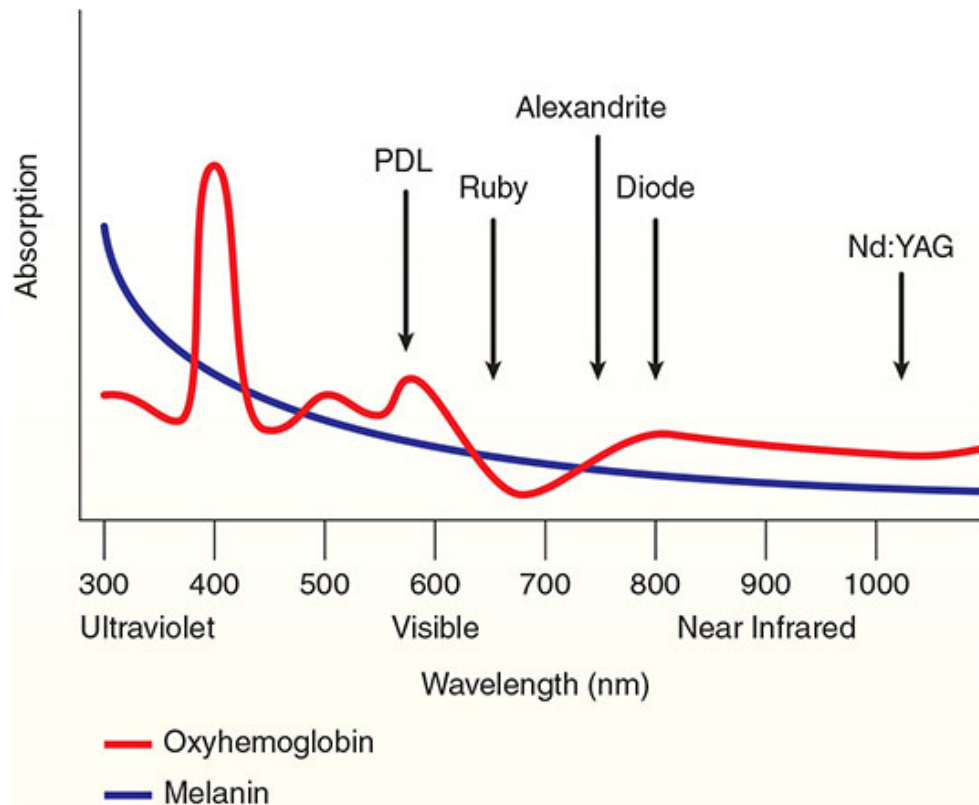


Figure 77-5. Absorption peaks for oxyhemoglobin and deoxyhemoglobin and relevant lasers.

The fourth broadband hemoglobin absorption peak from 700 to 1,100 nm becomes more important when targeting deeply seated vessels. In general, longer wavelengths penetrate more deeply into the skin with less scattering of photons and greater penetration to a deeper target. Not only do longer wavelengths penetrate more deeply, but they also heat the target more uniformly.

The pulse duration is determined by the thermal relaxation time; larger diameter telangiectasias require longer pulse duration to allow sufficient time for diffusion of heat evenly throughout the cylindrical vessel ([Table 77-1](#)). Shorter pulse durations may be needed for smaller vessels, but can result in excessive heat and vessel rupture, and thus increased risk for purpura. In general, longer pulse durations of at least 6 ms (and up to 40 ms) are used for telangiectasias to decrease risk for purpura. Larger spot sizes result in less scattering and deeper penetration.

Table 77-1. Thermal Relaxation Times According to Vessel Diameter

Diameter (Micrometer)	Thermal Relaxation Time (Microseconds)
10	0.048
20	0.19
50	1.2
100	4.8
200	19.0
300	42.6

While delivering a sufficient quantity of energy to thermocoagulate the target vessel, the overlying epidermis should be unharmed. This requires minimization of absorption by melanin and some mode of protective epidermal cooling. A number of different laser and IPL systems have been developed with this goal in mind. Cooling may be applied by direct contact, cold gel, cold air blowing, or spray cryogen. Cooling may also be applied before, after, or continuously during the laser pulse. In patients with higher Fitzpatrick skin types, there is a risk of depigmentation, hypopigmentation, and postinflammatory hyperpigmentation with cryogen spray if excessive. Contact cooling can be achieved via sapphire crystal, quartz, or copper. Sapphire crystal maintains cold temperatures better than the others. With contact cooling it is important to maintain proper contact with the skin, otherwise the risk of epidermal damage increases. Fluence needs to be adjusted on the basis of baseline vessel temperature; the colder the vessel from prechilling, the higher the fluence required.

Table 77-2 lists the most commonly used lasers to treat erythema and telangiectasias. Pulsed-dye lasers (PDLs), potassium titanyl phosphate (KTP) laser, alexandrite laser, Nd:YAG, and infrared diode lasers as well as IPL devices are typically used. There are several caveats when considering a laser of choice. KTP laser is actually a laser beam generated by a neodymium-doped yttrium aluminum garnet (Nd:YAG) laser, which is then directed through a KTP crystal to produce a coherent light in the visible green portion of the spectrum. The 532-nm wavelength is one of several hemoglobin absorption peaks. Absorption of melanin is significant, and thus KTP lasers are not recommended for those with Fitzpatrick skin types above III or patients who are significantly tanned.

Table 77-2. Commonly Used Lasers and Energy Devices for Erythema and Telangiectasias

Laser or Energy Device	Wavelength (nm)
Pulsed-dye laser (PDL)	595
Potassium titanyl phosphate (KTP)	532
Intense pulsed light (IPL)	Varying and multiple
Alexandrite	755
Neodymium-doped yttrium aluminum garnet (Nd:YAG)	1,064
Diode	Infrared wavelengths (i.e., 800, 810, 900, 940, 980)

PDL produces light in the yellow spectrum and has less absorption by melanin. The alexandrite laser is significantly absorbed by epidermal melanin, and so is best for patients with lower Fitzpatrick skin types. As the 1,064-nm wavelength's interaction with melanin is much less than that of other laser wavelengths utilized for hemoglobin, its use allows treatment of skin types up to Fitzpatrick V, something not possible with other wavelengths. Because the Nd:YAG laser heats water within the epidermis and dermis, there is a higher risk of overheating the skin with possible resultant epidermal/dermal injury, and eventual hypopigmentation, depigmentation, atrophy, and scarring. Therefore, the smallest spot size and lowest energy should be adopted when using this wavelength. In addition, clinical endpoints, such as blurring of vessels, can be less clearly visible, so there is a risk of overtreatment and thus increased risk of side effects. Lastly, diode lasers have varying wavelengths in the infrared region which pick up the fourth peak of hemoglobin, but are infrequently used to treat vascular lesions as there is a risk of epidermal damage. Historically they were used more often, but with the advent of lasers specific for hemoglobin their use has declined.

An IPL device consists of a noncoherent flash lamp that delivers controlled amounts of yellow, red, and infrared wavelengths to the skin. Theoretically, a device that produces a noncoherent light as a continuous spectrum longer than 550 nm should have multiple advantages over a single

wavelength laser system. First, both oxygenated and deoxygenated hemoglobin should simultaneously absorb at these wavelengths. Second, larger blood vessels should be affected more than with a single wavelength. Third, thermal absorption by the exposed blood vessels should occur with less overlying epidermal absorption, as the longer wavelengths will penetrate deeper. Other advantages of this device are large spot sizes and the ability to control pulse duration and the length of the intervals between pulses, the latter of which is only possible with certain devices.

For IPL treatment of erythema and telangiectasias, shorter cutoff wavelength filters should be chosen; the value on the filter designates the shortest wavelength within it. Multiple filters may be employed to gain more selectivity, and notched filters are also now available with select systems. IPL devices satisfy the criteria for selective photothermolysis, permitting blood vessels to be selectively heated over the surrounding tissue. Pulses are typically separated to allow thermal relaxation time and cooling of the epidermis in between pulses. Modern IPL units include contact cooling and sapphire crystals to protect the skin.

The principles of laser treatment of erythema and telangiectasias are outlined in [Table 77-3](#). Lasers should be analyzed in terms of the color of light they produce.

Table 77-3. Principles of Laser Treatment for Telangiectasias and Erythema

Smaller, superficial, bright red vessels need shorter wavelengths of green or yellow	■ Green—532 nm (KTP) ■ Yellow—585–595 nm (PDL) ■ Multiple (IPL)—500–670, 870–1,200 nm
Deeper blood vessels require longer wavelengths or infrared	■ Alexandrite—755 nm ■ Diode—800–980 nm ■ Nd:YAG—1,064 nm
Other points	■ Larger blood vessels need longer pulse durations ■ Spot size diameter should be double the size of target vessel ■ Pigmented skin will be damaged by visible light wavelengths ■ Skin types greater than type III should only be treated by infrared wavelengths

Discussion

Telangiectasias

For the treatment of telangiectasias of the face, including the nose, the most commonly used lasers are PDL and KTP, as these are specific for targeting intravascular oxyhemoglobin. The pulse duration should reflect the size of the vessel; the smaller the diameter of the telangiectasia, the shorter the pulse duration. The Vbeam Perfecta (Syneron Candela, Irvine, CA), a PDL, has a spot size of 3×10 mm which is useful for treating the linear shape of telangiectasias, though a 10- or 7-mm spot size can be used as well, particularly when treating telangiectatic matting. Cooling is achieved by a patented dynamic cryogen spray cooling just before the laser pulse. The pulse durations, longer than with the original PDL, can extend from 10 to 40 ms, which allows treatment of facial vessels with less purpura. Treatment results can be enhanced by partial overlapping of pulses and pulse stacking, as appropriate.

The KTP 532-nm laser is also very effective.² A comparative study of 532-nm versus 595-nm laser for treatment of telangiectasias and erythema demonstrated that the KTP is slightly more effective than PDL, though it is also associated with more swelling and redness.³ After one treatment, the KTP achieved 62% clearing versus 49% with the PDL. In the study, the settings for the PDL (Candela) were 10 mm, 7.5 J/cm², and 10 ms and for the KTP, from (Laserscope, now Cutera), were 5 to 10 mm, 9 to 10 J/cm², and 10 to 23 ms.

With regard to energy settings, it is best to start at the lower range of recommended energy settings that are programmed into the lasers and increase as needed, as the preset parameters were established by company-sponsored clinical evaluations. The endpoint is constriction of the vessel or a brief purplish to grayish color of the vessel. Settings with the Excel V (Cutera) range from 5 to 7 mm, 8.6 to 9 J/cm², and 8 to 10 ms, with contact cooling.

The alexandrite and diode are infrequently used for treatment of telangiectasias. At 755 nm, the alexandrite laser demonstrated strong absorption by melanin, explaining its infrequent use; while it is beneficial for the treatment of larger and deeply placed telangiectasias, it can only be used in those with lower Fitzpatrick skin types. Ross et al. published a study using a 755-nm laser for treatment of facial telangiectasias in 19 patients with Fitzpatrick skin types I and II; a 6-mm spot size was used with a mean fluence of 88 J/cm² and pulse durations ranging from 20 to 80 ms.⁴ After one treatment, there was 48% clearance of vessels; of note, one patient developed a scar, demonstrating that this risk exists with these lasers. The diode laser has a similar risk for epidermal damage. Tierney et al. compared the 532- to a 940-nm diode for treatment of facial telangiectasias.⁵ They found similar efficacy in resolution of small telangiectasias, but the diode was better for larger diameter telangiectasias.

IPL can be used for treating telangiectasias, and is often the treatment of choice when larger areas need to be treated on the face, neck, or chest due to larger available spot sizes. Equivalent efficacy to the PDL has been demonstrated.⁶ Purpura is uncommon, and when it does occur, it typically fades quickly. A similar endpoint of vessel constriction and mild to moderate erythema should be achieved; there should not be a gray “footprint” of the IPL crystal, as that indicates epidermal injury. IPL device choice is based in

part on the spot size; some devices, such as the StarLux Icon Max G or Y (Cynosure, Westford, MA), have large spots sizes (4.5×1 cm and 1.5×1 cm, respectively), which work well for treating larger areas. The Lumenis M22 (Lumenis Aesthetics, Yokneam, Israel), also has both large and small spot sizes (3.5×1.5 cm and 1.5×0.8 cm) available. Smaller spot sizes are useful on the nose or forehead, where avoiding the eyebrows is needed. Both devices use a sapphire crystal cooling system.

For telangiectasias that have a diameter of 1 mm or larger, a longer wavelength, such as the 755- or 1,064-nm laser, may be used; start with a lower fluence and spot size and increase as needed.^{4,7} The Excel V and CoolTouch Varia (Syneron Candela, Roseville, CA) are often used for 1,064-nm treatments. With Excel V a spot size of 5 mm, 110 J/cm^2 , and 30 ms may be used; the cooling on this device is contact cooling via a sapphire crystal, and ultrasound gel may be used as well. For the CoolTouch Varia, a spot size of 3.5 mm with energies of 160 to 175 J/cm^2 , and 30 ms may be used; cooling is via cryogen spray. With blue 2- to 3-mm veins, greater fluences may be necessary.

Telangiectasias of the nose can be very treatment resistant; recurrence rates are quite high, necessitating maintenance treatments. IPL has a good success rate with minimal side effects when using adequate gel and contact cooling with skin. The VBeam Perfecta with longer pulse durations and the 3×10 -mm spot size are also very effective.⁸ Although the Nd:YAG is sometimes utilized for nasal vessels, particularly purple telangiectasias, caution should be exercised as excessive heat buildup may occur leaving pockmarks and linear depressions on the nasal ala. At least 2 seconds should elapse between each 1,064-nm laser pulse, and skin cooling needs to be effective to reduce the risk of overheating and subsequent collagen overcontraction. Stacked pulsing should never be used. This can lead to undissipated heat from excess nonspecific heating of the water in the dermis and result in necrosis. For this reason, Nd:YAG is rarely used on the nose. In many patients, it can be difficult to permanently eliminate alar telangiectasias altogether; caution patients from the outset that maintenance treatments are often necessary.

Diffuse erythema

For the treatment of erythema of varying etiologies on the face, neck, and chest, the PDL, KTP, and IPL are most commonly utilized. All have demonstrated reproducible efficacy.⁹ A study comparing IPL to PDL for treatment of erythematotelangiectatic rosacea demonstrated similar efficacy after three treatments spaced 1 month apart (Figs. 77-6 and 77-7). For the PDL, the settings were 10 mm, 7 J/cm², and 6 ms and for the IPL a 560-nm filter, a pulse train of 2.4 and 6.0 ms in duration separated by a 15-ms delay, and a starting fluence of 25 J/cm² were used.¹⁰ Again, for practical purposes, the IPL is typically utilized for the chest and neck, though any device may be used. Longer pulse durations for the KTP and PDL may be used to avoid purpura. With the Excel V 532 nm, energies of 7 to 9 J/cm², pulse durations of 8 to 20 ms, and a 10-mm spot size may be used.



Figure 77-6. A 38-year-old woman with erythematotelangiectatic rosacea at baseline.



Figure 77-7. The same patient 2 years later after undergoing IPL treatments every 6 to 12 months to control her signs and symptoms.

Poikiloderma of Civatte

Poikiloderma of Civatte is a combination of epidermal and dermal atrophy, increased pigmentation, and enhanced vascularity. Its occurrence is strongly associated with a history of excessive sun exposure. Patients typically present in the third to fifth decades and are usually of lower Fitzpatrick skin

types. Invariably, poikiloderma of Civatte is located on the lateral and anterior neck and upper chest with sparing of sun-protected sites, such as the submentum. Because this is a combination of hyperpigmentation and increased vascularity, treatment with the noncoherent, multiple wavelength IPL is very effective. Weiss et al. published data on 135 patients with poikiloderma of the neck and chest treated with IPL, with over 75% of patients achieving clearance¹¹; there were minimal side effects. These results have been reproduced in other studies.¹² In addition, both patients and treating physicians have noted an improvement in skin texture and fine lines when using IPL. This initially was an incidental finding in early studies, but given the concomitant atrophy typically seen with poikiloderma, it is a significant additional benefit. Lastly, IPL confers the added advantage of having larger spot sizes, increasing treatment efficiency. Therefore, IPL is generally the first choice for poikiloderma treatment.

KTP and PDL can be utilized as well, but care must be taken to use larger spot sizes and reduced energies. PDL is best reserved for poikiloderma that is primarily composed of dilated blood vessels without hyperpigmentation. Some of the “brown” hyperpigmentation perceived with the naked eye may actually be deoxygenated hemoglobin.¹³ PDL is generally more painful for patients. Another factor for the physician to consider when treating large areas is the wear and tear to the laser itself—larger areas consume more of the dye kit and cryogen.

Regardless of the device chosen, a slight amount of overlap of pulses is necessary to achieve uniform improvement of the treated area. Skip areas can lead to visible “footprinting,” which may be in the shape of the device treatment head. This can be reduced by performing more than one pass in different directions, or by changing the orientation of a rectangular crystal at subsequent treatment sessions. This improves with repeated treatments, but patients should be warned ahead of time of the risk of “footprinting” or blotchy improvement. Poikiloderma requires a series of treatments, typically between 3 and 5, and strict sun protection should be advised.

STEP-BY-STEP GUIDE

Every procedure should be preceded by patient education and informed consent. A good outcome depends on both an adequate medical response to

therapy and a satisfied patient. Patient satisfaction depends not only on the technical success of the procedure, but also, and sometimes more so, on their expectations. The expectations of the patient and the doctor should be same before beginning any treatment.

Patients should be educated that there are risks associated with every procedure and that no procedure guarantees an excellent outcome every time. The patient must understand that medicine is not an exact science and that there is no guarantee he or she will be satisfied with the end results. Patients should be given time to ask questions and to receive complete answers. One should not proceed with treatment until one feels comfortable with the patient's understanding and expectations. It is difficult to establish the appropriate physician-patient relationship with patients who are unreasonable, overly demanding, or unable to comprehend the basics of treatment planning and outcomes. These types of patients are also the most likely to complain about any aspect of their treatment.

For the treatment of erythema and telangiectasias, standardized photos with proper and consistent lighting should be taken. Patient consents should be signed and dated prior to procedures. Potential risks include, but are not limited to, purpura, edema, blistering, pigmentary changes, and scarring. Clarification of patient expectations and review of the likely need for multiple treatments and possible maintenance treatments are necessary, and ultimately enhances the patient experience. In addition, patients should be instructed on proper sun-protective measures, particularly for erythema caused by rosacea and actinic damage.

On the face, neck, or chest, patients may or may not receive topical anesthesia. In general, vascular lasers and IPL are well tolerated, so topical anesthesia is not necessarily indicated. Some patients find treatment of large areas of the face sufficiently painful with PDL that they request topical anesthetic. If topical anesthesia is to be used, it is important that it does not contain phenylephrine, as this will cause vasoconstriction of the target vessels. If necessary, cold air blowing devices or application of chilled rollers (Cynosure, Westford, MA) allows comfortable treatment without topical anesthetic. As with any procedure, the skin should be clear of makeup, lotions, creams, or other topical products prior to commencing laser treatment. Patients may clean with soap and water followed by wiping the skin with alcohol pads.

Proper eye protection for patients, assisting staff, and the treating provider is critical. Laser goggles should have an optical density (OD) of at least 4. When treating on the face, it is best for patients to use metal goggles or disposable laser or IPL-rated eye adhesive pads. Treatment within the orbital rim requires the use of intraocular eye shields. Do not use the deeply penetrating Nd:YAG wavelength within the orbital rim.

A laser warning sign should be visible on the outside of the door. Prior to commencing the laser treatment, ensure that the proper foot pedal is in place and recheck the laser settings and cooling. For lasers that have more than one wavelength, recheck the selected wavelength, and that glasses are appropriate. Following treatment, some clinicians apply triamcinolone 0.1% cream and perform a light-emitting diode (LED) 40-second treatment using GentleWaves (L'Oreal, Ile-de-France, France) to possibly decrease the inflammatory response.¹⁴ Patients should be instructed to call if they have unexpected swelling or bruising. If patients experience significant swelling following treatment, there are a number of adjunctive agents that may be used, including topical steroids, antihistamines, oral prednisone, and diuretics.

Telangiectasias

For a patient presenting with nasal or facial telangiectasias, the long-pulsed PDL, Vbeam Perfecta, KTP/Nd:YAG, or IPL may be used (Fig. 77-8). For telangiectasias of the neck or chest, the larger spot-sized IPL devices allow more efficient treatment, with appropriate judicious adjustment of fluence.



Figure 77-8. A 55-year-old male presented with worsening facial telangiectasia (*left*). Note the marked improvement after three treatments with both 1,064 nm for the larger telangiectasias and 532-nm treatment for the smaller telangiectasias (*right*).

1. Most laser devices for treatment of vascular lesions are based on a fiber delivery system with a contact or dynamic cooling device. For contact cooling devices, a water-based gel is placed directly on the skin, and the crystal or spacing device is held directly against the skin. In contrast, for dynamic cooling, no gel should be used because the cryogen cools the skin. Gel is not necessary with PDL, and may introduce water that diminishes the fluence before reaching the target vessels. Minimal pressure is placed against the skin, as the target may be compressed with excessive hand pressure. Treatment parameters are outlined in [Tables 77-4 and 77-5](#). See also for utilizing both KTP and PDL for treatment of nasal telangiectasias.

Table 77-4. Treatment Parameters for Facial, Chest, and Neck Telangiectasias Using PDL and KTP

	Pulse Duration (ms)	Energy (J/cm ²)	Spot Size (mm)	Cooling
Excel V	Facial: 8–10 Neck/chest: 10–15	Facial: 8.6–9 Neck/chest: 6–8	Facial: 5 Neck/chest: 12	5°C and ultrasound gel
Excel V: Skin type III	8–12	7–10	5–7	5°C and ultrasound gel
VBeam Perfecta	6–10	11–14	3 × 10	Cryogen
VBeam Perfecta	6–10	5.5–8	10	Cryogen
VBeam Perfecta	6–10	7–12	7	Cryogen
VBeam Perfecta	6–10	7.5–12.5	5	Cryogen

Table 77-5. Treatment Parameters for Nasal Telangiectasias Using PDL and KTP

	Pulse Duration (ms)	Energy (J/cm ²)	Spot Size (mm)	Cooling
Excel V	8–10	8.6–9	5	5°C and ultrasound gel
Excel V: Skin type III	8–12	7–10	5–7	5°C and ultrasound gel
VBeam Perfecta	10–40	10–13.5	3 × 10	Cryogen
VBeam Perfecta	10–40	6.5–8.5	10	Cryogen
VBeam Perfecta	10–40	8–12	7	Cryogen
VBeam Perfecta	10–40	8–12	5	Cryogen

2. If using an IPL device, use the filter with cutoffs at 560 to 590 nm. Rarely, the 515-nm cutoff filter can be used in patients with type I or II skin. For devices that have fixed filters, use an IPL head that produces green or yellow wavelengths. If a contact cooling device is utilized, a small layer of water-based or coupling gel is placed on the skin. With minimal pressure, the cooling device with crystal is placed directly onto the skin

overlying the targeted area. No pressure is applied, as the target vessels collapse with compression leaving very little target. [Figure 77-9](#) shows placement of the IPL crystal with gel on the skin. An immediate gray tone to the skin in the shape of the crystal is not desirable; pronounced erythema and urtication in the shape of the crystal should be avoided as well. The Cynosure ICON MaxG for the face and MaxY for the neck and chest may be used at 10 to 20 ms and 25 to 42 J/cm² and the Lumenis One at 3 ms, double pulse, with 10 to 20 ms off time between pulses at total fluence of 14 to 20 J/cm². The ICON has the added advantage of the SkinTel, which determines the patient's melanin index and suggests a range of safe treatment parameters based upon that. Extended pulse durations may be used for larger nasal telangiectasias with pulse durations of 40 to 50 ms ([Figs. 77-10](#) and [77-11](#)). Pulse stacking can be done on the face, nose, neck, and chest, and enhances efficacy. During a lengthy treatment, some device crystals may start to warm up; one must be alert for this. Treatment parameters are outlined in [Table 77-6](#) and demonstrated in.

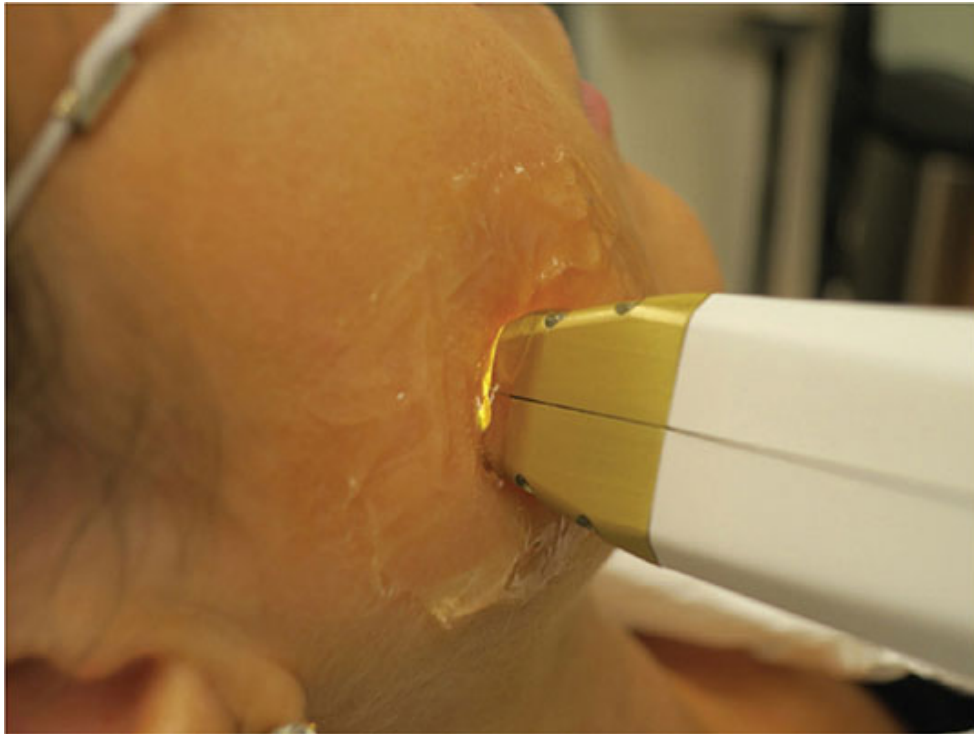


Figure 77-9. IPL device with cooling gel on the skin.

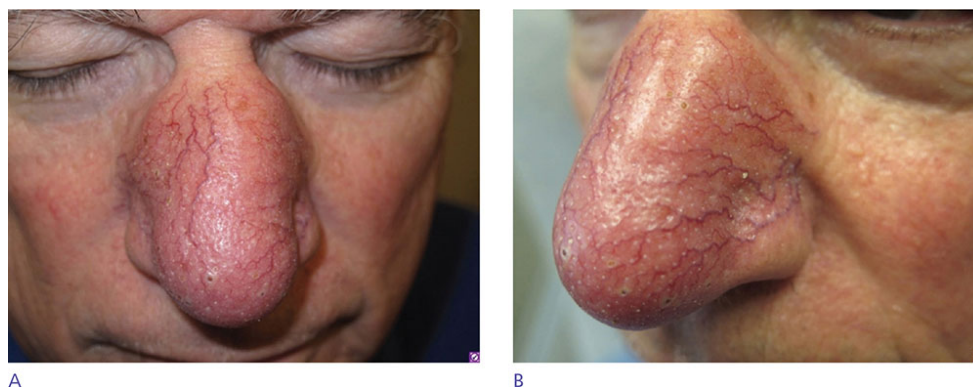


Figure 77-10. A 65-year-old male presented with rhinophymatous rosacea. He was treated with a combination of Vbeam Perfecta and Excel V (both KTP and Nd:YAG) given the combination of diffuse erythema and large discrete telangiectasias. Care was taken not to pulse stack with the Nd:YAG, whereas pulse stacking was utilized with the PDL.

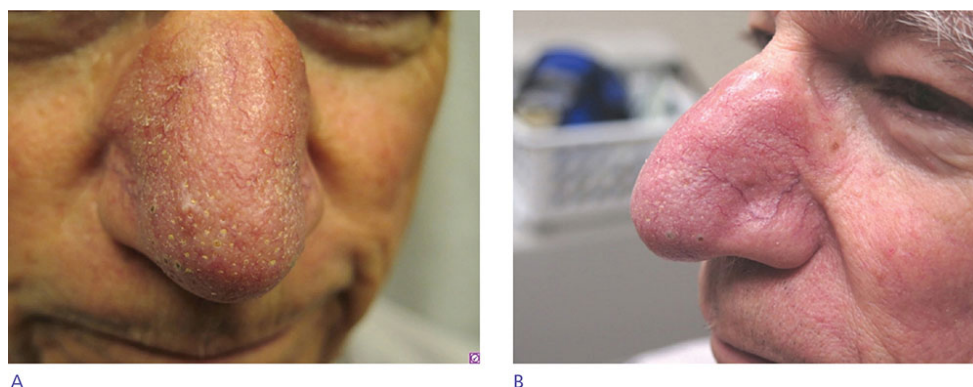


Figure 77-11. The same patient after a series of four treatments.

Table 77-6. Treatment Parameters for Facial, Nose, Neck, and Chest Telangiectasias Using IPL

For vessels < 0.2 mm in diameter	■ Lumenis One: 3.0 ms, 560-nm filter, 14–20 J/cm² ■ StarLux Max G: 5–10 ms, 20–36 J/cm²
For vessels 0.2–0.4 mm in diameter	■ Lumenis One: 2.5/2.5 ms (10-ms delay), 560-nm filter, 14–22 J/cm² ■ StarLux Max G: 10 ms, 30–40 J/cm²
For vessels 0.4–0.8 mm in diameter	■ Lumenis One: 2.4/7.0 ms (10–15-ms delay), 590-nm filter, 15–24 J/cm² ■ StarLux Max G: 10–20 ms, 30–46 J/cm²

3. Regardless of the light source or laser utilized, there are some features and pitfalls common to all devices. Typical endpoints include immediate vessel contraction, visible intravascular photodarkening, which represents intravascular coagulation, or rupture of the vessel causing immediate purpura. In general, purpura may be avoided without compromise of efficacy, and purpura causes significant patient downtime. The pulse duration should be extended when purpura is encountered. If vessel constriction is not noted, either the energy needs to be increased or the pulse duration may need to be increased, as the entire vessel may not be heating. The risk of hyper- or hypopigmentation from overcooling the skin with cryogen also exists. Blanching is to be avoided with all devices. For the PDL and KTP lasers and IPL, up to three passes may be performed over the treated area.
4. With the 1,064-nm lasers, the Cutera Excel V or CoolTouch Varia is commonly used; there are multiple lasers available with similar wavelengths. For telangiectasias of the nose (not ala), face, neck, or chest a pulse duration of 30 ms, fluences of 110 to 120 J/cm², spot size of 5 mm, and cooling at 5°C may be used. Lateral spread of thermal effects within the vessel beyond the point of treatment is frequently noted so that overlap is not necessary; pulses should be spaced out by at least 1 mm. Stacked pulsing, which can be performed with PDL and KTP, should never be utilized for infrared lasers, particularly 1,064-nm lasers. The 1,064-nm laser is especially effective at treating blue 1 to 3-mm telangiectasias of the forehead.

Poikiloderma of Civatte

For the treatment of poikiloderma of Civatte, the IPL is used most frequently, though PDL or KTP may be used as well, particularly if there are clearly visible telangiectasias (Figs. 77-12 and 77-13). If the latter situation is present, two to three passes may be performed with an IPL followed by treatment of the larger vessels using either PDL, KTP, or Nd:YAG. The large telangiectasias may also be treated first, followed by the IPL.



Figure 77-12. A 50-year-old female with extensive actinic damage presented with poikiloderma of Civatte (note the unrelated surgical scar).



Figure 77-13. Marked improvement in erythema after four IPL treatments.

1. When using the IPL for treatment of poikiloderma, similar settings are used as to when treating telangiectasias (Table 77-6). At least two passes may be performed at each visit. One pass can be done at 20 ms to target larger vessels, and the second at 10 ms to target dyspigmentation. If the vessels are particularly large, the pulse duration can be increased to 50 to 60 ms, and energy to around 50 J/cm² or even higher, depending on the patient's skin type and response. Devices such as the Lumenis One and newer IPL sources typically have preset or recommended settings for clinical findings such as poikiloderma of Civatte.
2. If using the Vbeam Perfecta, a spot size of 10 or 12 mm, pulse durations of 6 to 10 ms, and energies of 5 to 7 J/cm² can be used. Although quicker pulse durations may decrease the number of total treatments, the resulting purpura on the neck and chest is usually not well liked by patients. Purpura is frequent with the 2-ms pulse duration.
3. For KTP, a spot size of 10 or 12 mm, approximately 7 to 9 J/cm², and pulse duration of 8 to 10 ms would be used.

For patients presenting with facial, neck, or chest erythema, PDL, KTP, or IPL devices may be used on the face, with IPL alone used on the neck and chest. See Tables 77-7 and 77-8 for treatment parameters.

Table 77-7. Treatment Parameters for Facial, Nose, Neck, and Chest Poikiloderma of Civatte and Erythema Using IPL

Poikilo- derma and erythema	■ Lumenis One: 2.5–3.0 ms, 10–15-ms delay, 560- or 590-nm filter, 14–22 J/cm² ■ StarLux Max G: 10–20 ms, 22–46 J/cm²
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Table 77-8. Treatment Parameters for Erythema of Face, Nose, Neck, and Chest Using KTP or PDL

	Pulse Duration (ms)	Energy (J/cm ²)	Spot Size (mm)	Cooling
Excel V	8–20, typically start with 10	7–9, typically start at 7.4	10	5°C and ultrasound gel
Excel V: Skin type III	8–20, typically start at 12	7–9, typically start at 7	10	5°C and ultrasound gel
VBeam Perfecta	6–10	5–8	10	Cryogen
VBeam Perfecta	6–10	8–11	7	Cryogen

CONCLUSIONS

Erythema and telangiectasias are a common problem, and patients frequently present to the dermatologic surgeon eager to address these concerns. Most telangiectasias can be managed using laser and light devices without causing significant purpura, though immediate postprocedure edema, as well as other local reactions, may be seen. An array of devices may be used, though IPL is the mainstay of therapy for telangiectasias and is an efficient and cost-effective approach to telangiectasia management.

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CHAPTER 78 Approaches to Facial Rejuvenation

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SUMMARY

- Improvement in skin quality and texture may be seen with the use of chemical peels, laser and light devices, dermabrasion, and skin needling.

- All approaches share the common mechanism of controlled wounding and stimulation of a healing response in the skin.

Beginner Pearls



- Use a pre-peel regimen of either topical tretinoin or hydroquinone cream to improve efficacy and outcomes.
- Be consistent in application technique and document all the parameters of the treatment process (pre-peel regimen, degreasing regimen, and peel regimen) to achieve consistency and predictability in results.
- Feather the peels around the hairline and the chin to prevent a sharp demarcation, particularly with medium and deep peels.

Expert Tips



- Medium-depth chemical peels are an excellent modality for the treatment of diffuse actinic keratoses.
- Multiple studies have shown that a combination approach using a topical regimen with serial chemical peels can improve melasma.
- Phenol peels have also been used as an adjunct to, or a less invasive alternative to, blepharoplasty.

Don't Forget!



- When applying the peel, numerous parameters such as the pretreatment regimen, degreasing regimen, type of application, length of peel application, and end-point should all be considered and documented.
- Pretreatment with topical tretinoin daily for 2 weeks prior to the procedure results in a more rapid, uniform, and even frosting of the skin compared to no pretreatment.

Pitfalls and Cautions



- Evaluate for any areas of inflamed skin on the day of treatment. These regions will have greater uptake of the peel solution and may create a deeper than intended reaction.
- Be cautious when using newly opened chemical solution bottle for the first time. The clinician should be particularly vigilant about clinical endpoints. On rare occasions, the concentration advertised on the label may not accurate.
- Avoid accidental treatment of eyebrows/eyelashes/hair when using IPL, as this device can be used for laser hair removal with longer pulse durations. At best, the inadvertent treatment of eyebrows results in a temporary loss of hair, and at worst it can lead to permanent decreased hair density.

Patient Education Points



- The consultation appointment is key in establishing rapport and realistic expectations, including that a series of treatments may be needed.
- Patient selection is critical given the discomfort, extensive healing process, and potential for adverse events associated with phenol peels.

CHAPTER 78 Approaches to Facial Rejuvenation

INTRODUCTION

The aged appearance of the face is caused by multiple factors including skin texture and quality, volume loss, and muscle movement. These factors contribute variably in each person depending on environmental exposure and genetic differences. In fact, when comparing people of a similar age, there can be a dramatic difference in the apparent age due to these factors. Improvement in skin quality and texture may be seen with the use of chemical peels and laser and light devices. Although other modalities, such as dermabrasion and skin needling, are available, all approaches share the common mechanism of controlled wounding and stimulation of a healing response in the skin.

CHEMICAL PEELS

Chemical peels are a fast, reliable, effective, and inexpensive method of wounding the skin under controlled conditions to induce skin regeneration. While the concept of applying topical solutions to rejuvenate the skin has been practiced for centuries, dermatologists pioneered the scientific study of using chemical solutions to produce targeted, predictable, and reproducible effects on the skin.¹ In trained hands, chemical peel solutions can be used to treat a diverse array of concerns including acne vulgaris, actinic keratosis, melasma, and photodamage. Scientific research on the effect of these peels is

challenging given the cosmetic nature of these procedures and difficulty with obtaining biopsy samples from facial locations. The number of peels on the market also increases annually with new concentrations, formulations, and combination agents available. In addition, variations in application technique between physicians and variations in patients' response to wounding make extrapolation of results unreliable.

Chemical peels are generally classified according to the relative depth of wounding (Table 78-1). Very light superficial peels penetrate only the stratum corneum, primarily acting as exfoliants, whereas superficial peels penetrate down to the basal layer of the epidermis. Medium depth peels reach the papillary dermis, while deep peels may reach the reticular dermis. While the relative depth of penetration of each compound is generally established by its chemical properties (acidity, toxicity, and metabolic interaction with endogenous proteins), the patient's inherent skin characteristics as well as the surgeon's application technique will impact penetration depth. Treatment location may also lead to variations in results. The same peel applied in the same manner may not penetrate as deeply on the forehead, where the skin is thicker and more sebaceous, compared to the preauricular cheek or the eyelid skin.

Table 78-1. Chemical Peel Classification Guidelines^a

Peel Type	Histologic Depth	Chemical Peel Solution
Very Light Superficial	Stratum corneum	Salicylic acid Glycolic acid 30–50% Jessner's solution, 1–3 coats TCA 10–20%
Superficial	Basal layer of epidermis	Glycolic acid 50–70% Jessner's solution, 4+ coats TCA 20–30%
Medium	Papillary dermis	TCA 35–40% TCA 35% + Jessner's solution TCA 35% + Glycolic acid 70% TCA 35% + Solid CO ₂
Deep	Reticular dermis	Phenol 88% Baker–Gordon phenol

^aThese are guidelines. Actual depth of penetration depends on a multitude of factors, including patient skin characteristics and application techniques.

When performing chemical peels it is best to establish a consistent technique to improve the predictability of outcomes. In general, as the ablative depth increases, so does the potential for adverse effects. When selecting a peel solution, the ablative depth of the chemical peel should correspond to the histologic depth of the targeted concern. This selection should be tailored to each patient. To minimize adverse events, appropriate pre- and post-peel regimens should also be in place.

Salicylic acid solution

Salicylic acid is the most popular β -hydroxy acid used in chemical peeling. Unlike other chemical solutions, its lipophilic nature allows it to penetrate into sebaceous glands and hair follicles. It is keratolytic and comedolytic, removing intercellular lipids and desmosomes, thereby decreasing the cohesiveness between corneocytes and keratinocytes.² As a

superficial peel, this solution is well tolerated even in patients with Fitzpatrick skin types IV to VI.³

There are numerous formulations for salicylic acid peels but the most common is a 20% to 30% salicylic acid solution in an ethanol base. The skin should first be prepped with acetone to degrease the skin. The peel can then be applied in two to three coats and left on for 3 to 5 minutes starting with the forehead, then the cheeks, nose, cutaneous lip, and chin. There is no need for neutralization. The skin will develop a light frost as the ethanol evaporates and salicylic acid precipitates, signaling completion of the peel. To achieve an even peel, more solution can be applied until the faint frost is evenly distributed. The patient can then rinse and cleanse the face with a gentle and bland facial cleanser.

Patients will experience an initial mild stinging sensation, lasting around 3 minutes, which can be alleviated with a cool fan.⁴ This discomfort is transient since the peel has anesthetic properties. Side effects are generally mild and transient, with the most common being dryness. While postinflammatory hypo- and hyperpigmentation have been reported in patients, particularly in areas of inflamed skin, this is transient, even in patients with Fitzpatrick skin type IV and greater.³ While salicylic acid is generally well tolerated it should not be used in patients who are pregnant or breastfeeding as it is pregnancy category C. Care should also be taken to avoid using this peel with lasers or dermabrasion given the flammable ethanol base.

Glycolic acid solution

Glycolic acid is the most popular α -hydroxy acid used for chemical peels. As the α -hydroxy acid with the smallest molecular size, it is thought to have better penetration compared to other compounds. Even though it is a naturally occurring compound found in sugar cane, clinical formulations are typically synthesized. It is provided as a crystalline solid, which must first be dissolved and then applied to the skin. The formulations can vary greatly in concentration, pH and vehicle, and the clinician should be aware of these factors as they all affect its efficacy. As the concentration of glycolic acid increases, so does penetration and tissue wounding.^{5,6} The free form of glycolic acid causes greater tissue damage compared to partially neutralized

or esterified formulas at the same concentration (Table 78-2).⁵ Formulations in an aqueous solution have greater bioavailability and penetration compared to gel formulation.⁷

Table 78-2. Glycolic acid formulations

■ Free acid
■ Partially neutralized
■ Buffered
■ Esterified

There are numerous formulations marketed to the consumer as part of a daily regimen, ranging in concentration from 8% to 20%.⁷ In concentrations of 3% to 13% applied twice daily, glycolic acid has been shown to improve xerotic skin's texture and moisturization.⁸ At these low concentrations, glycolic acid decreases corneocyte cohesiveness by reducing sulfate and phosphate groups, leading to exfoliation and a superficial peel. Stronger glycolic acid peels such as the 50% and 70% formulation are typically applied in the clinicians' office. At these higher concentrations, glycolic acid can induce subepidermal vesiculation with dermal inflammation, resulting in the induction of new dermal collagen and ground substance as the skin heals.^{5,6}

No preparatory agent is used prior to applying the peeling agent. Patients will experience stinging and irritation with application of the glycolic acid peel, but tolerability can be improved with a hand-held cooling fan. The endpoint for this peel is a uniform level of erythema, which is typically achieved in 2 minutes, though the peel may be left in place up to a limit of 5 minutes. If regions of the skin start to blanch or frost, this may be an indication of deeper penetration and epidermolysis, and the peel should be stopped with neutralization. To neutralize the glycolic acid peel, either a bicarbonate solution or cool water can be used. If a bicarbonate solution is used, patients should be told to expect fizzing and warmth during the exothermic reaction. Glycolic acid peels can also be neutralized with water to avoid the reaction, but any remaining solution must be completely rinsed away to completely remove the acid.

Glycolic acid, like salicylic acid, is generally well tolerated and can be used in a wide range of Fitzpatrick skin types, but unlike salicylic acid, the penetration can be less predictable at higher concentrations.⁹ To minimize the risk of a deeper peel than intended, patients can be asked to stop topical retinoids 3 to 7 days prior to their peel, since tretinoin can lead to a dermatitis and deeper penetration of the glycolic acid. If deeper penetration does occur, patients may experience essentially a medium depth peel with increased erythema, edema, desquamation, and a prolonged healing time. Inflammatory conditions such as seborrheic dermatitis may cause uneven and deeper penetration and skin affected by these conditions must be treated cautiously. Care should also be taken in how many applications and how long the solution is applied as these can both increase the wound depth. A practical approach to the treatment-naïve patient is to start with a 50% concentration with short contact time and progressively increase at subsequent treatments as tolerated. If a superficial peel is achieved, any postprocedure hyperpigmentation or hypopigmentation should be transitory. Nevertheless, patients should always be counseled on proper sun protection, as glycolic acid acts as a photosensitizer.¹⁰ In addition to the risk for pigmentary changes, a small number of patients may experience a perioral acneiform dermatitis, in which case further peels on the chin should be avoided.⁷

Jessner's solution

Jessner's solution is composed of 14-g salicylic acid, 14-g resorcinol, 14-g lactic acid, and ethanol up to total volume of 100 mL. By combining multiple peeling agents, the physician can provide the benefits of each individual component while minimizing the risk profile from any single agent (Fig. 78-1). As a result, Jessner's solution achieves keratolysis and exfoliation with a good safety profile. It can be used alone as a superficial peel or, more commonly, used in combination with TCA as a medium-depth peel. As the solution is applied, patients may experience stinging and irritation, similar to a salicylic acid peel. The clinician should look for a mild frost, likely precipitated salicylic acid, as well as mild erythema as primary endpoints. If applied in one to three coats a very superficial peel is achieved. With more coats, a more pronounced frost and deeper penetration can be achieved, but

is generally still limited to the epidermis.¹¹ Overall the peel is well tolerated but patients may experience dryness and tightness post-peel in conjunction with the expected exfoliation. This peel is also titratable via changes to the degreasing procedure with acetone or alcohol. Variations in the intensity of the degreasing scrub or length of time allows for further customization of the peel depth.



Figure 78-1. Jessner's peel: Pretreatment (A, B); 1 month posttreatment (C, D).

Trichloroacetic acid solution

Trichloroacetic acid (TCA) solutions are versatile and can be used as superficial or medium depth peels, depending on the concentration and regimen used. Solutions of TCA vary in concentration between 10% and 35%. TCA exists in a crystalline form and needs to be dissolved in water in the appropriate weight to volume ratio. To create a 35% solution, 35 g of crystal is dissolved in 100 mL of water. This solution is not sensitive to light and is stable at room temperature.⁷ Even though higher concentrations of TCA have been used in the past to achieve deep peels comparable to Baker–Gordon phenol, modern concentrations are generally less than 40% to decrease the risk of scarring, hypopigmentation, and erythema.¹²

To achieve a superficial peel, TCA is applied as monotherapy. The skin should be degreased appropriately and then followed by a thin layer of TCA at 10% to 30%. Like other peel solutions, the higher the concentration, the deeper the penetration. The clinician should use a speckled white frost as the clinical endpoint for a light peel, at which point cool wet gauze is applied to neutralize the peel. Unlike salicylic acid or Jessner's peel, the frosting results from coagulation of skin proteins, and can be used to gauge the patient's response to the peel.

To achieve a medium depth peel, 35% TCA can be combined with other superficial peeling agents such as Jessner's solution, solid CO₂, or 70% glycolic acid to target more pronounced photodamage, dyschromia, lentigines, and seborrheic keratoses. The Jessner's and 35% TCA combination (Monheit combination) is popular since both peel solutions are commercially available (Figs. 78-2 and 78-3). The skin is degreased with acetone or alcohol and then treated with Jessner's solution. Once the patient achieves a speckled frost and mild erythema with Jessner's solution, gauze soaked in cool water is applied to the skin. This initial peel removes the stratum corneum and decreases cohesiveness between keratinocytes, allowing greater penetration of the TCA solution. Since the skin has already been prepped and treated, a second degreasing step is not needed between the Jessner's and TCA steps. TCA 35% can be applied in light strokes or with more vigorous rubbing. The clinician should be aware that each successive application and deeper application pressure causes deeper penetration of the solution. The clinician should look for a moderate frosting and erythema as the primary endpoints, followed by cool compresses.

Patients can expect post-peel erythema, edema, and peeling, with re-epithelialization within 7 to 10 days.¹²

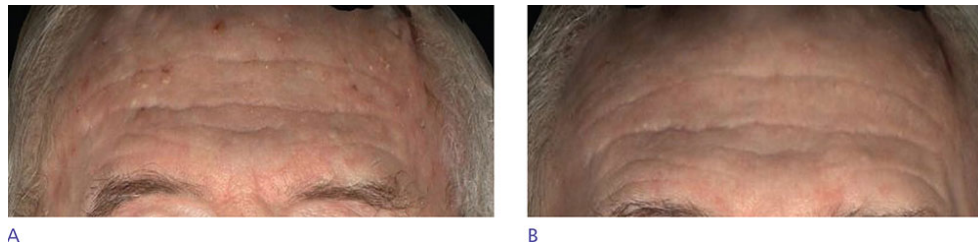


Figure 78-2. Jessner's + 35% TCA medium depth peel: Treatment of actinic damage—pretreatment (A), posttreatment (B).

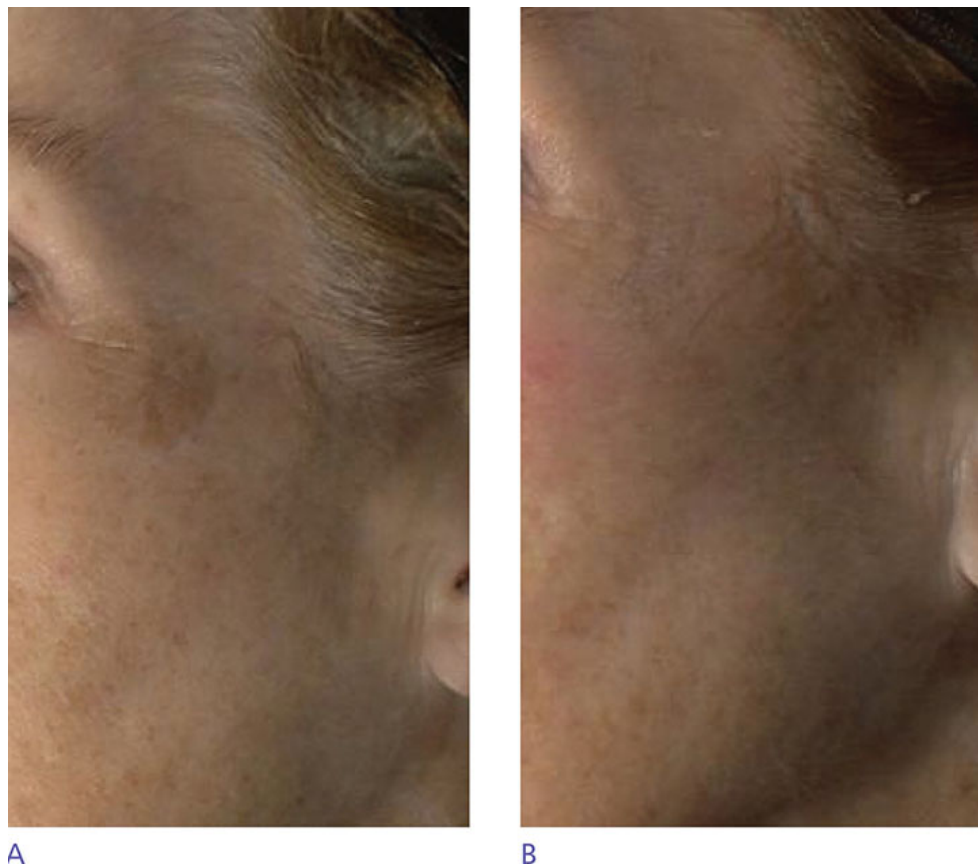


Figure 78-3. Jessner's + 35% TCA medium depth peel: Treatment of a thin seborrheic keratosis—pretreatment (A), posttreatment (B).

Biopsies taken from the skin after peeling with four coats of Jessner's solution showed changes limited to the epidermis without dermal changes. In contrast, when Jessner's is combined with a single coat of 35% TCA, dermal

edema and an inflammatory infiltrate could be seen shortly postoperatively.¹¹ One month later, new collagen fibers can be seen in the upper reticular dermis. When Jessner's solution is followed by three coats of 35% TCA, the result is more prominent postoperative epidermal necrosis and edema followed by robust collagen generation as well as an increase in ground substance in the upper reticular dermis.¹¹

Thirty-five percent TCA can also be applied following an initial treatment with solid CO₂ (Brody combination). This achieves a more robust medium depth peel, similar to Jessner's, with three coats of 35% TCA.¹¹ To apply solid CO₂ a small piece is broken off to fit the clinician's hand and then dipped in a 3:1 solution of acetone and alcohol and glided over the skin. Solid CO₂ removes the stratum corneum and physically damages the epidermis, creating epidermal vesiculation. As the CO₂ is applied with increasing pressure, the epidermal damage also increases, allowing greater penetration of the TCA solution.¹¹ This can be helpful when customizing treatment for hyperkeratotic regions.

When solid CO₂ is followed by a single coat of 35% TCA, biopsies show more prominent epidermal necrosis, similar to that achieved by Jessner's and three coats of 35% TCA. When solid CO₂ is combined with three coats of 35% TCA, new collagen fibers can be seen in the upper reticular dermis, accompanied by an increase in ground substance extending to the reticular dermis.¹¹

Similar to the concepts behind the Monheit and Brody combinations, 35% TCA can also be applied following 70% glycolic acid to achieve a deeper peel (Coleman combination). In this technique, free 70% glycolic acid can be applied directly to the skin without degreasing for 2 minutes. After 2 minutes the skin is rinsed and then followed by the 35% TCA solution. Biopsies taken posttreatment have demonstrated a thickened papillary dermis, but less than that achieved by the Brody technique.¹³ Like the Monheit combination, glycolic acid is readily available in the clinician's office. 70% glycolic acid is less predictable than Jessner's solution, however, and care must be taken to avoid inadvertently causing greater penetration in areas of inflamed skin.

Aside from full-face TCA peels, high concentrations of TCA have also been used in the treatment of depressed ice-pick acne scars using the CROSS method (chemical reconstruction of skin scars), discussed in detail below.

Phenol-based solution

Phenol-based peels provide the deepest chemical ablations and can be used for etched-in wrinkles resistant to all other peels. The most common formulation used is the Baker–Gordon phenol solution (Table 78-3).¹⁴ This formulation should be freshly prepared and frequently stirred to ensure an exact and even concentration is applied. There have been many modifications to this original formulation, including the Exoderm and Venner-Kellson solutions, which are better tolerated with an improved safety profile and less penetration.^{15,16} As with the previously discussed peels, penetration is not solely determined by the formulation. While increasing concentrations of phenol and croton oil lead to greater tissue damage, the application technique itself is important; more vigorous application with greater coats leads to a deeper peel and more inflammation.^{17–19}

Table 78-3. Phenol Peel Formulations

Baker–Gordon Solution	Exoderm Solution	Venner–Kellson Solution
3-mL 88% phenol	1-mL 91% phenol	8-oz melted loose phenol crystals
2-mL distilled water	1-mL phenol crystal	1-oz concentrated Lysol
8 drops of Septisol	0.5-mL distilled water	0.5-oz olive oil
3 drops of croton oil	0.5 mL mixture (alcohol, olive oil, glycerin oil, sesame oil)	1.5-oz distilled water
	2 drops of croton oil	10 drops of croton oil
	0.3-mL resorcin	
	10 drops of soap	
	0.2-cc citric acid	
	Buffer tris	

Patient selection is critical given the discomfort, extensive healing process, and potential for adverse events associated with phenol peels. Patients are commonly put under sedation for their comfort, as the process can otherwise be painful. Patients should also have cardiac monitoring and intravenous hydration throughout the procedure to minimize the risk of cardiotoxicity. The patient's face is first cleansed and degreased with acetone. This is followed by application of a thin layer of freshly mixed Baker's formula using cotton-tipped applicators, taking care to avoid excess solution. This is applied first to the forehead, then the cheeks and perioral and nasal skin. The entire procedure should be performed slowly over 60 to 90 minutes to slow the systemic absorption of phenol and decrease the risk of cardiotoxicity. The skin will immediately frost due to protein coagulation as each site is treated. To delay the absorption, the clinician should wait 15

minutes between each cosmetic unit. Each zone should be feathered out into the surrounding skin to avoid sharp demarcation between treated and untreated regions. Patients should have cardiac monitoring throughout the procedure and for 1 hour postoperatively. Once completed, the peel can either be left open or placed under occlusion with waterproof zinc oxide tape. If left open, patients should be counseled to expect erythema and edema and to apply petrolatum ointment liberally twice daily. Unoccluded phenol peels have penetration similar to medium depth peels, so patients should expect faster healing times. For deeply etched wrinkles, patients will need a phenol peel occluded by waterproof zinc oxide tape placed in overlapping strips over the entire treated surface. This should be left on for 24 to 48 hours. At the return visit any drainage or excess exudate can be gently removed. A second mask formed from bismuth subgallate powder can then be applied with reapplication of the powder at home as needed for the next week. By the end of the week the skin will have re-epithelialized and this second mask is removed with petrolatum ointment and warm compresses.^{7,16}

When performing deep peels, the clinicians should be aware of potential complications. In a study of 43 consecutive patients undergoing phenol-based peels, half of the patients who had their peels completed within 30 minutes developed cardiac arrhythmias compared to none of the patients who had their peel completed over at least 60 minutes.²⁰ The arrhythmias included premature ventricular contraction (4), bigeminy (2), paroxysmal atrial tachycardia (2), and ventricular tachycardia (2), with no correlation with age (range 24- to 73-year-olds). In the 10 patients who developed arrhythmias, 9 had unremarkable preoperative EKGs.²⁰ The incidence of cardiac arrhythmias can be reduced when precautions such as intravenous hydration, proper ventilation, and prophylactic propranolol are given. In a retrospective case series of 181 patients treated with a full-face Exoderm phenol peel, which slows the absorption of phenol compared to the traditional Baker–Gordon formula, 6.6% of patients still developed an arrhythmia when the treatment was completed over 30 minutes despite concurrent treatment with intravenous hydration, 1 mg of prophylactic propranolol, and an electric fan and air conditioned room to improve ventilation.²¹

Aside from cardiac complications, phenol peels are also susceptible to hyperpigmentation, hypopigmentation, prolonged erythema, and scarring. Even though the Exoderm modified phenol peel decreases the risk of adverse

events, a case series involving Asian patients still showed frequent side effects including postinflammatory hyperpigmentation (74%) and prolonged erythema of more than 3 months (11%).²² Hypopigmentation was rare, but did occur in 1 of 46 patients (2%).

Similar to TCA solutions, phenol can also be applied as monotherapy at high concentration in the treatment of depressed acne scars. Because the application area is limited, this targeted treatment method has low absorption and an improved risk profile, but patients should still be counseled on the risk of dyschromias and erythema.

Preoperative evaluation of the patient

Skin characteristics

When assessing the patient for a chemical peel, the first and foremost consideration should be the patient's skin type and characteristics. Even with the same application technique, differences between patients can significantly alter the penetration of chemical peels and affect their safety and efficacy. In selecting the appropriate peel, the dermatologic surgeon must first consider the patient's tendency for postinflammatory hyperpigmentation. Patients with Fitzpatrick's skin types IV to VI ([Table 78-4](#)) have a greater risk of postinflammatory dyschromia. While superficial peels carry less risk for adverse events such as hyperpigmentation, hypopigmentation, or scarring, patients should still be given an appropriate pre-peel regimen and practice sun protection post-peel.² Test spots in less cosmetically sensitive locations can also be performed prior to a full procedure. In addition to patients' natural tendencies toward pigmentation, inherent skin texture can also affect the efficacy of the peel ([Table 78-5](#)). Areas of active inflammation allow deeper penetration of chemical solutions compared to surrounding skin, leading to deeper ablation. Patients with rosacea, in particular, may experience greater inflammation and are at greater risk of prolonged erythema post-peel. Patients with thin and translucent skin will similarly experience greater ablation with greater risk for adverse events. In contrast, patients with thick sebaceous skin or those with hyperkeratotic lesions will experience less penetration and must be prepped appropriately to elicit the intended reaction. Similarly, with the same peeling regimen, areas of the face

with thinner skin will experience greater penetration compared to areas of thicker skin.⁵

Table 78-4. Fitzpatrick Skin Type Classification Scale

Skin Type	Characteristics
Type I	Always burns, never tans
Type II	Usually burns, tans with difficulty
Type III	Sometimes burns, gradually tans
Type IV	Rarely burns, tans with ease
Type V	Very rarely burns, tans very easily
Type VI	Never burns, tans very easily

Table 78-5. Patient Evaluation

Patient Characteristics	Skin Characteristics
Patient’s desired results	Tendency for postinflammatory hyperpigmentation <i>Fitzpatrick skin type</i>
Tolerance for postoperative management and downtime	Areas of active inflammation <i>Rosacea, dermatitis, etc.</i>
Willingness to undergo multiple treatments	Skin texture <i>Thin, translucent vs. sebaceous or hyperkeratotic skin</i> Glogau classification

Medical and surgical history

When taking a medical history, the physician should probe for any risk factors associated with poor healing and poor outcomes (Table 78-6). Patients with a history of hypertrophic scars or keloid formation should be limited to very light superficial peels to avoid dermal damage. Those with an active herpes simplex virus infection should wait until active sores are healed and then treated prophylactically prior to their procedure to avoid

triggering another outbreak and dissemination of the virus on resurfaced skin. If a history of HIV or nicotine use is elicited, the patient should be counseled regarding the potential for delayed wound healing. Patients with recent isotretinoin use should also be counseled regarding the risk for delayed healing and abnormal scarring, even with superficial peels. While there have been case series questioning the need to delay peels for 6 or 12 months after completion of isotretinoin therapy, there are case reports of scarring and prolonged hyperpigmentation and erythema in patients with recent low-dose isotretinoin use, even when treated with superficial peels.^{23,24} In one such case, the patient had previously tolerated 70% glycolic acid while on isotretinoin without any adverse events, suggesting that reactions may be unpredictable and idiosyncratic.²³

Table 78-6. Factors to Elicit from Past Medical and Surgical History

Medical History	Surgical History
Keloid/hypertrophic scars	Prior radiation exposure
Recent isotretinoin use (previous 6–12 months)	Prior facial surgery
Herpes simplex virus	
HIV or other immunosuppression	
Nicotine use	
Pregnancy and breast feeding status	
Oral contraceptive or other photosensitizers	
Staph infection	
Hypersensitivity to any peel components	

When eliciting surgical history, the physician should probe for any history of radiation or prior facelift or browlift. Radiation decreases the vasculature and density of pilosebaceous units from which the skin regenerates, thereby delaying healing. Similarly, if the patient has had prior facial surgery with

extensive undermining, the superficial plexus may be disrupted in the immediate postoperative period, delaying healing. Finally, female patients of child-bearing age should also be questioned about any possibility of being pregnant or if they are breastfeeding.

Evidence-based surgical technique considerations

When performing chemical peels, selecting the appropriate agent is important, but this must be combined with the appropriate technique to obtain the intended effect. When applying the peel, numerous parameters such as the pretreatment regimen, degreasing regimen, type of application, length of peel application, and end-point should all be considered and documented (Table 78-7). If the patient returns for a repeat treatment and is happy with their previous response, the surgeon can then reproduce the same results. In contrast, if the patient had adverse events from previous applications, the surgeon can then adjust the application technique to modulate the effects.

Table 78-7. Surgical Techniques Affecting Peel Depth

Priming regimen
Degreasing regimen
Chemical peel scrub intensity
Number of coats applied
Length of peel application

Pre-peel regimen

The chemical peel procedure begins even before application of the chemical solution itself. Pretreatment with topical tretinoin daily for 2 weeks prior to the procedure results in a more rapid, uniform, and even frosting of the skin compared to no pretreatment. Tretinoin helps reduce sebum and thins the stratum corneum prior to the peel, improving the efficacy of the peel without an appreciable increase in adverse events.²⁵ Pretreatment with topical tretinoin also speeds re-epithelialization. In a double-blind, placebo-controlled, prospective, randomized split-face study evaluating pretreatment with tretinoin 0.1% cream versus a placebo vehicle, 75% of the hemifaces

pretreated prior to a 35% TCA peel showed complete re-epithelialization at 1 week, compared to only 31% of the placebo-treated hemifaces.²⁵

In patients at risk of postinflammatory hyperpigmentation, pretreatment for 2 weeks with hydroquinone decreases postprocedure hyperpigmentation compared to no pretreatment or pretreatment with 0.025% tretinoin cream.²⁶ In a single-blind, randomized prospective study of patients assigned to glycolic acid treatment alone (group I), glycolic acid preceded by 2 weeks of 0.025% tretinoin cream (group II), or glycolic acid preceded by 2% hydroquinone cream (group III) for the treatment of melasma, both patients' subjective response and objective observer's response indicated better outcomes in group III. While 20% of patients in the glycolic acid-only group developed postinflammatory hyperpigmentation, this was decreased to 14.3% and 5.5% in the groups pretreated with tretinoin and hydroquinone, respectively.²⁶ These results were corroborated by another double-blind, randomized controlled trial comparing pretreatment with 2% hydroquinone versus 0.025% tretinoin for 2 weeks prior to a medium-depth TCA peel in patients with Fitzpatrick skin type III and greater.²⁷ Postinflammatory hyperpigmentation was limited to the group of patients pretreated with tretinoin and not seen in those pretreated with hydroquinone. While no studies evaluated the benefit of hydroquinone pretreatment prior to deep peels, a randomized controlled trial evaluating pretreatment (10% glycolic acid twice daily, hydroquinone 4% cream nightly, and tretinoin 0.025% cream twice daily) for 2 weeks prior to ablative CO₂ resurfacing showed no benefit in decreasing posttreatment hyperpigmentation compared to the group which received no pretreatment.⁵⁵ Since ablative laser resurfacing wounds the skin to the dermis, similar to a deep chemical peel, while hydroquinone pretreatment may be effective for superficial and medium depth peels, it will likely be ineffective in preventing postinflammatory hyperpigmentation after deep chemical peels.

For patients with Fitzpatrick skin types I to II, tretinoin 0.025% cream can be used nightly for 2 weeks prior to peel. In patients with Fitzpatrick skin type III or higher, hydroquinone 4% cream can be used twice daily for 2 weeks prior to superficial and medium depth peels. Care must be taken, however, to evaluate for any dermatitis on the day the patients present for their peel. Since areas of inflammation allow greater and unpredictable

penetration of chemical peel solutions, delay peels if the dermatitis is deemed too exuberant.

Peel technique

The peel application starts with degreasing the skin to remove excess sebum and to even the stratum corneum to allow equal penetration of the peel solution. Sebum is lipophilic, and lipophobic solutions will not penetrate areas with residual sebum. Patients with oily or sebaceous skin can benefit from more vigorous degreasing scrubs. Numerous degreasing agents have been used in the literature, including alcohol, Septisol, ether, and acetone. Degreasing the skin with ether results in a deeper peel compared to milder cleansers such as acetone.¹⁴ Many dermatologic surgeons prefer using acetone. Hyperkeratotic lesions prevent penetration of the peel; appropriate areas can be targeted for a more vigorous scrub to thin the stratum corneum appropriately.

Once the degreasing is complete, the appropriate chemical solution is chosen and applied. The method of application (brush, gauze pad, cotton tip) should be standardized and documented since different techniques deliver different quantities of these solutions, altering their effects. The number of applications of the peel will also affect the peel's penetration. As the number of coats of the peel increases, so does the peeling depth, potential healing time, and risk for adverse events.^{11,19} The strength with which the peel is applied can also affect penetration depth. More vigorous applications with a back and forth motion deposit more solution. When using solid CO₂, increasing the strength with which the CO₂ is applied also results in deeper penetration.¹¹

Post-peel regimen

Patients should be counseled to expect erythema, edema, and either exfoliation or peeling depending on the chemical depth of their treatment. To help the skin heal, patients should limit their skin care regimen to a bland facial cleanser and a bland topical emollient. Occlusion is not recommended, unless specifically intended, after phenol peels. The patient should also avoid picking at the skin or using abrasive products such as scrubs, masks, toners, tretinoin, or hydroquinone until the skin has fully re-epithelialized. Erythema is normal post-peel, but if persistent erythema is seen at more than

3 weeks, it may be a sign of contact dermatitis or an impending hypertrophic scar and should be evaluated by the clinician.²⁸

Step-by-Step Chemical Peeling Protocol

Before a Jessner's peel, every patient is started on a 2-week regimen of tretinoin 0.025% cream nightly. If there is concern for postinflammatory hyperpigmentation, 4% hydroquinone can be used instead. On the day of the chemical peel, the patient is assessed to make sure the topical pre-peel regimen has not induced a severe dermatitis. Mild erythema and exfoliation are to be expected, but more severe inflammation makes the peel less predictable and would prompt a delay of treatment.

1. Lay out all the supplies needed on a Mayo tray (clean and dry 2×2 gauze, 4×4 gauze thoroughly soaked in a bucket of ice water, a stainless steel cup, 4×4 dry gauze, Q-tip dipped in petrolatum ointment, acetone, appropriate solution bottles). Provide a hand-held fan to the patient or an assistant to blow toward the face throughout the procedure.
2. Take a 2×2 gauze with acetone and scrub the skin to degrease it. Start with the forehead and temples (1 gauze pad), cheeks (1 gauze pad per cheek), chin/nose/cutaneous lips (1 gauze pad). Take 2 minutes to degrease the entire face and document the vigorousness of the scrub (gentle, moderate, vigorous).
3. Take petrolatum ointment on a Q-tip and apply a small amount to the corners of the nose and lips.
4. Take (1) 2×2 gauze and thoroughly soak this in a stainless-steel cup containing Jessner's solution and then wring it out. Use 1 gauze pad to wipe the forehead and temples while covering the eyes with the nondominant hand.
5. Take a fresh 2×2 gauze that has been soaked with Jessner's solution and then wring it out and apply on one cheek.
6. Repeat step #5 on the other cheek.

7. Take another fresh 2×2 gauze soaked in Jessner's solution and then wring out and apply to the chin, cutaneous lips, and nose. By this time, mild to moderate erythema as well as scattered mild frosting on the previously treated areas should be visible.
8. Take the 4×4 gauze pads soaking in cold ice water. Gently squeeze to remove excess water and then unfold and place on the patient, starting on the forehead and then moving to the subsequent areas that have been treated. Apply more cool compresses as needed for the patient's comfort.
9. After a few minutes the cool compresses can be removed, revealing scattered frosting and erythema.
10. The patient can wash their face with a bland facial cleanser and is instructed to continue using bland moisturizers and practice sun protection until complete resolution of the peel.
11. Patients may return in 1 week and 1 month to evaluate their progress and address any concerns.

Evidence-based indications

Acne

Medical management remains the first-line treatment for active acne, though chemical peels can be used as adjuvant therapy. Treatment of acne can be divided into therapies for active acne lesions and those for acne scars. Treatment and application regimens may differ between practitioners and are often not documented in detail in published case series, making extrapolation of results difficult. However, the superficial peeling agents (salicylic acid, Jessner's, glycolic acid, and low-concentration TCA) have all demonstrated efficacy in treating active acne lesions.

Salicylic acid peels, in particular, with their lipophilic and keratolytic properties, ease of application, and excellent safety profile, are commonly used. In a randomized single-blind prospective study comparing 30% salicylic acid peel versus Jessner's solution applied every 2 weeks for 12 weeks in patients with mild and moderate acne, salicylic acid was significantly more effective at reducing comedone count (53.4% vs. 26.3%,

$P = 0.001$).²⁹ For papules, the overall difference at the end of 12 weeks was not statistically significant, though the group treated with salicylic acid peels saw improvement earlier.²⁹ Patients from both groups experienced erythema and postinflammatory hyperpigmentation, but this was more frequent in the group treated with Jessner's solution. This study was corroborated by a separate group that found that 30% salicylic acid improved both comedonal and inflammatory acne and showed greater efficacy versus Jessner's solution for comedonal lesions.³⁰ In this second study, no change in inflammatory lesions was seen with Jessner's solution, but these results were only assessed after three peels, in contrast to six peels in the previous study.³⁰ In another prospective, double-blind, randomized split-face study comparing 30% salicylic acid versus 25% TCA in patients with Fitzpatrick skin types III to V, both treatments improved comedonal and inflammatory lesions with no statistical difference between the two groups. The authors noted no complications on the hemifaces treated with salicylic acid but did note prolonged erythema (25%) and hyperpigmentation (20%) in the group treated with TCA.³¹

Glycolic acid has also been found to be efficacious in the treatment of inflammatory and noninflammatory acne lesions. In one study using 70% glycolic acid applied for 2 to 8 minutes on the skin and repeated every 10 days as needed, the authors observed improvement with all stages of acne lesions, with comedonal acne improving the fastest followed by papulopustular acne and then nodulocystic lesions (average 3 treatments, 6 treatments, and 8–10 treatments, respectively). While nodulocystic lesions required more treatment sessions, the authors noted an additional benefit of improvement in superficial acne scars.³² In a separate prospective single-blind split-face study comparing 70% glycolic acid applied for 2 minutes versus Jessner's solution, the authors saw improvement in both arms with no clear superiority for either treatment.^{33,34} Glycolic acid has also been compared to salicylic acid in a head-to-head prospective randomized, double-blind split-face study of mild to moderately severe acne. In this study, 30% glycolic acid was applied to one hemiface for 4 to 5 minutes while 30% salicylic acid was applied for 4 to 5 minutes to the other side. Both treatments decreased the number of acne lesions without clear superiority at 1-month follow-up. At 2-month follow-up, however, the side treated with

salicylic acid had sustained this improvement while the side treated with glycolic acid demonstrated a trend toward more new lesions.

Acne scars are another common condition that have been studied by the chemical peel community. In 2002, the chemical reconstruction of skin scars (CROSS) technique was introduced.³⁵ A solution of high concentrations TCA (65% and 100%) is applied focally into the base of depressed acne scars using a sharpened wooden applicator to induce collagen regeneration (Figs. 78-4 and 78-5). Because the solution is focally applied, local anesthesia and sedation are not needed, and healing is faster than with traditional full-face peels. In the original 2002 case series, two blinded physicians evaluated pretreatment photos against those taken 6 months after treatment, and 15/15 patients receiving 6 or more treatment courses were deemed to have a good or excellent results (>50% improvement). In the group treated with 100% TCA, all patients receiving five or six courses showed excellent results (>70% improvement).³⁵ In this Asian population, both groups experienced equal frequency of posttreatment erythema and transient postinflammatory hyperpigmentation. Studies involving the CROSS technique using 70% TCA, 90% TCA, and 88% phenol have all been reported and demonstrated efficacy for ice-pick scars.^{36,37} In a split-face trial of 90% TCA versus 88% phenol, both sides showed significant improvement in scar grades pre- and posttreatment, but patients rated phenol as more painful (5.3 vs. 4.4) on a 10-point pain scale. Persistent erythema and hyperpigmentation were seen in both treatment sides, but hypopigmentation and widening of scars were seen only in the 90% TCA group (two patients each, 14.3%).³⁶ A similar case report of widening and atrophy of a scar was reported in a patient treated with an 80% TCA CROSS technique, suggesting that care must be taken in the application technique to limit the solution only to the scar depth.³⁸



A



B



C



D

Figure 78-4. CROSS technique: Frosting immediately upon application (A, B); early postop erythema (C, D).

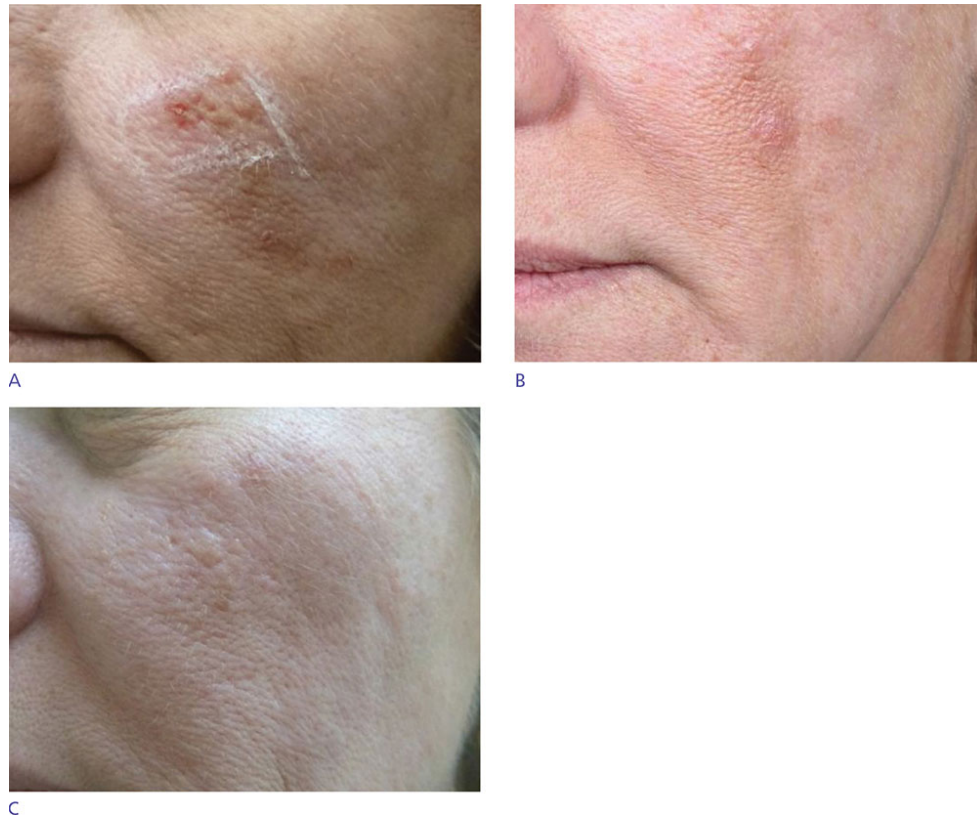


Figure 78-5. CROSS technique: Pretreatment (A); 3 months posttreatment (B); 2 years postop (C).

Actinic keratoses

Chemical peels are an excellent modality for the treatment of diffuse actinic keratoses. In a head-to-head nonrandomized split-face trial, patients were treated with a single application of Jessner's/35% TCA medium depth peel on the left side of the face and a traditional 3-week regimen of topical 5-fluorouracil on the right side of the face and then evaluated at 1, 6, and 12 months. Both sides received pretreatment with tretinoin 0.025% cream nightly for 2 weeks. Both hemifaces showed a significant reduction in the number of actinic keratoses (75%), with neither showing superiority at any follow-up endpoint.³⁹ This was confirmed histologically by biopsies taken at the 1-month follow-up, which showed significant reduction in hyperkeratosis and parakeratosis compared to pretreatment biopsies. In a questionnaire completed at the 6-month visit, all but one of the respondents reported preference for the chemical peel due to the convenience of a single treatment and the shorter healing time.³⁹

In contrast to medium depth peels, superficial peels alone are often inadequate in the treatment of actinic keratoses. In a prospective, randomized, controlled split-face study evaluating weekly application of glycolic acid alone versus glycolic acid with 5-fluorouracil over 8 weeks, the sides treated with the combination (fluohydroxy pulse peel) demonstrated a 92% (range 81–100%) reduction in AK compared to only 20% in the monotherapy group ($P < 0.05$).⁴⁰ Both investigators and patients reported preference for the side treated with the combination therapy. In addition to the reduction in actinic damage, there was also improvement in the overall cosmesis with reduction of solar lentigines, telangiectasias, and rhytides.

Melasma

Melasma is an acquired hyperpigmentation disorder that is challenging to treat. Medical therapy remains first-line and consists of sun protection with some combination of hydroquinone, tretinoin, and a topical steroid, but patients often show variable results and recurrence is high. Chemical peels can be used as an adjunct therapy and numerous variations in treatment regimen have been reported in the literature. In general, serial treatments are needed to prevent relapse, combination treatments are better than monotherapies, and postinflammatory hyperpigmentation remains a risk factor.

Melasma is commonly divided into epidermal, dermal, and mixed types with the aid of a Wood's lamp. Most studies use superficial peeling agents to target the epidermal and dermal pigmentation and deeper peels to target mixed pigmentation. In a split-face trial comparing Jessner's solution versus 70% glycolic acid applied for 2 minutes applied 1 month apart over 3 months, both sides achieved improvement with an average MASI score decrease of 8.61, with no superiority in either arm.⁴¹ While this decrease is on par with what has been reported with medical therapy alone, the improvement occurred over 3 months as opposed to 10 months. Interestingly, however, Wood's lamp illumination to determine the depth of pigment was not useful in predicting clinical response. Another study investigating the effect of 55% to 70% glycolic acid and 10% to 15% TCA in 100 patients showed that half of the patients required fewer than 5 peels while half required 5 to 10 peels. While the patients treated with TCA required fewer number of peels (4.1 vs. 6.1), this group also experienced higher rates of

relapse and hyperpigmentation (25% vs. 5.9%).⁴² Of note, no discussion was made of a priming regimen.

Multiple studies have shown that a combination approach using a topical regimen with serial chemical peels can improve melasma. In two independent studies, when patients were primed with hydroquinone 2% or tretinoin 0.025% cream nightly for 2 weeks prior to a series of six peels (10% TCA in one study, 20%+ glycolic acid in the second), both groups showed an initial improvement that was comparable, but the group treated with hydroquinone experienced longer duration of their effect with less relapse.^{26,27} In another study evaluating the additional benefit of serial glycolic acid peels, patients were randomized to either medical therapy alone (topical azelaic acid 20% cream and adapalene 0.1% gel) or medical therapy with a series of eight glycolic acid peels (35–70%). The combination treatment group achieved an 83% decrease in mean MASI score, compared to 69% in the medical treatment group.⁴³

Other peels have also been studied in the use of melasma. The data on serial salicylic acid are mixed, with one study reporting efficacy and another finding no improvement. A randomized, single-blind study divided 60 patients with epidermal melasma into two groups treated with either Jessner's solution (34) or 30% salicylic acid (26). Patients were primed with 0.05% tretinoin cream for 2 weeks and counseled to use SPF 60 sunscreen and then treated biweekly over 12 weeks (six treatments) with their respective chemical agents. Both groups saw statistically significant improvement, as measured by their MASI score at the end of the treatment period and at the 4- and 12-week follow-up visits.⁴⁴ No superiority in either arm was detected. A more recent prospective, randomized, controlled, split-face trial of epidermal melasma compared a series of four salicylic acid peels applied biweekly in conjunction with 4% hydroquinone cream versus hydroquinone cream monotherapy. While both treatment regimens showed improvement by the treatment end, no superiority was seen with the addition of salicylic acid peels.⁴⁵

Melasma is a difficult condition to treat. It is difficult to conceptualize the mechanism for superficial peels to improve dermal melasma. It may be that the majority of melasma is mixed and the improvement seen in dermal melasma is that of the epidermal component. To offer patients the best chance of success, patients should be primed and maintained on a topical regimen

which includes hydroquinone with an expectation that serial peels will be needed to achieve improvement, but relapse will likely recur.

Facial rejuvenation

Facial rejuvenation and improvement of photoaging is one of the primary applications for chemical peels. To guide clinicians in the assessment of photodamage, the Glogau classification can be used in assessing the patient (Table 78-8). Superficial peels can improve skin texture and mild hyperpigmentation while medium depth peels target more extensive actinic damage and fine lines. For deeper etched-in lines, however, deep peels should be used. Glycolic acid is one of the most popular superficial peels for facial rejuvenation. Patients can be given a pre-peel regimen of tretinoin and/or low concentration glycolic acid cream and then peeled with serial glycolic acid treatments with increasing concentration (50–70%) as their skin tolerance allows. For the treatment of wrinkles and solar lentigines, 70% glycolic acid may be left on for 4 to 8 minutes.⁴⁶ The beneficial effects of glycolic acid have also been tested and confirmed in a prospective placebo-controlled split-patient study evaluating a 50% glycolic acid gel formulation applied for 5 minutes on the face, forearm, and hands compared to a vehicle control. After 4 consecutive weekly treatments, patients were evaluated by blinded evaluators both clinically and by biopsy. Across the three site locations, glycolic acid significantly improved rough skin texture, the number of actinic keratoses, and fine wrinkling, as compared to control ($P < 0.0001$ for all parameters).⁴⁷ Coarse wrinkling, however, was unaffected. Clinical improvement correlated with changes in biopsy as well, with a more compact stratum corneum and a thicker epidermis with a more prominent stratum granulosum.

Table 78-8. Glogau's Classification for Photoaging

Group	Severity	Age Group	Wrinkles	Other Features
I	Mild	20–35	Minimal wrinkling	No keratoses No—little makeup No pigmentation changes
II	Moderate	35–50	Easy wrinkling	Early palpable actinic keratoses Few seborrheic keratoses Small amounts of makeup
III	Advanced	51–65	Wrinkles at rest	Obvious actinic keratoses Obvious seborrheic keratoses Always wears makeup
IV	Severe	66+	Deep wrinkles and wrinkles throughout	Yellow-gray skin color History of skin cancers Makeup “cakes and cracks”

Adapted with permission from Tung R, Rubin M. *Procedures in Cosmetic Dermatology Series: Chemical Peels*, 2nd ed. Philadelphia: Elsevier/Saunders; 2011.

Other superficial peeling agents have also been reported to be efficacious in the treatment of mild photodamage. In the original report of 30% salicylic acid peel, the authors describe their experience in a case series of 50 patients with mild to moderate photodamage. The majority of patients experienced subjective improvements in skin texture, light pigmentation, and fine lines.⁴ A single application of 35% TCA peel has also been compared against a series of five peels with 30% glycolic acid in a split-face study. While the improvements at 3 months were small and not visible to naïve judges, patients subjectively reported better outcomes with the 35% TCA peel and an image analysis software detected fewer fine lines on the 35% TCA treatment side.⁴⁸ While this is not the full Jessner's/35% TCA medium depth treatment regimen, this study does show that patients unwilling to undergo a deeper peel may need serial treatments with a superficial peeling agent to obtain a similar result.

For patients with severe photoaging with less tendency toward pigmentation, deeper phenol-based peels are preferred due to their dermal penetration. To “tighten” wrinkles, the peel needs to penetrate into the reticular dermis so that collagen regeneration can occur.^{49,50} Of the various phenol-based formulations, the original Baker–Gordon solution has the greatest penetration.¹⁵ In their 1974 publication, Baker and Gordon et al. followed patients they had previously treated for clinicopathologic correlation. The histologic changes posttreatment that they had reported earlier, including increased dermal collagen and elastic tissue, were visible in patients up to 13 years after treatment, leading the authors to conclude that the architectural and clinical changes induced by deep peels are permanent.⁵¹ Since then, modifications in phenol peels have been used in treating photoaging. In a recent publication, a group of patients were treated with 88% phenol applied focally every 3 mm along fine wrinkles using a punctuated method similar to the CROSS technique. Since the application was limited, the authors reported no downtime and patients were not sedated. The clinical improvement in wrinkle appearance correlated with a thicker dermis, like that seen in a full-face peel, without the associated recovery time and risk profile.⁵²

Phenol peels have also been used as an adjunct to, or a less invasive alternative to, blepharoplasty. In post-blepharoplasty patients treated with a modified phenol formulation, a majority of patients noted improvement in

wrinkling and pigmentation. While some wrinkling recurred posttreatment, the authors reported an overall permanent improvement with the treatment.⁵³ In a separate study, phenol peels were used as a less invasive alternative to blepharoplasty, with good clinical outcomes. In a case series of eight patients with Fitzpatrick skin types I to III with mild to moderate upper eyelid ptosis, a Baker–Gordon phenol peel was applied to a focal region of excess skin on the upper eyelids followed by 88% phenol to the remaining periorbital skin. The peel was left unoccluded after treatment and healing time was approximately 6 to 8 days, similar to the periorbital areas treated with 88% phenol and 35% TCA applied elsewhere on the face. The authors reported no adverse effects and a significant increase in eyelid gap posttreatment.^{54–56}

LASER- AND LIGHT-BASED TREATMENT

Facial rejuvenation is a rapidly growing area of aesthetic medicine, and energy-based devices are commonly and effectively utilized to achieve this goal. In 2015, dermatologists performed over 2 million energy-based treatments.⁵ Energy-based rejuvenation devices are an active area of basic science and industry research, and patients today have more treatment options than ever before. These devices that function by selectively heating, and thus altering, target tissues. This is most commonly achieved with light-based devices, but rejuvenation can also be accomplished by using radiofrequency, ultrasound, or even cooling (as is the case with cryolipolysis). Light-based treatment is based on the foundational theory of selective photothermolysis.⁵⁷ Photothermolysis is selective as target chromophores absorb an optimal wavelength of light. The chromophore is thus affected while leaving the surrounding skin unchanged. The primary chromophores of interest in photoaging include hemoglobin (telangiectasias), melanin (lentigines), and water (atrophy and rhytides) (Table 78-9).⁵⁸

Table 78-9. Indications, Commonly Used Wavelengths, Pulse Durations, and Tissue Endpoints for Chromophores

Chromophore	Indication	Commonly Used Wavelengths	Pulse Duration	Tissue Endpoint
Hemoglobin	Telangiectasia, cherry angioma, port-wine stain	532, 595, 755, 1,064	Milliseconds	Transient intravascular purpura (nonbruising), purpura and ecchymosis
Melanin	Lentigines	532, 595	Nanoseconds, milliseconds	Superficial graying of target lesion
	Hair	755, 810, 1,064	Milliseconds	Destruction of hair with perifollicular urticaria/erythema
Tattoo pigment	Cosmetic tattoo, traumatic tattoo	532 (red, yellow, orange, brown), 694, 755, 1,065 (green, blue, black)	Picoseconds, nanoseconds	Superficial whitening of target lesion
Water (nonablative)	Photoaging, rhytides	1,430, 1,550, 1,927, Intense pulsed light (~560–1,400)	Milliseconds	Erythema
Water (ablative)	Photoaging, rhytides, nonspecific tissue destruction (verruca, benign nevi, other benign cutaneous neoplasms)	2,490, 10,400	Milliseconds	Tissue ablation, erythema

Note: immediate blister formation is never an intentional tissue endpoint.

Both full-field and fractionated devices are used in clinical practice. Full-field devices emit their energy to an entire treatment area of skin, but are selective by utilizing the specific absorption spectrum of their target tissue. Common devices include pulsed-dye laser (PDL, 595 nm), potassium titanyl phosphate laser (KTP, 532 nm), and intense pulsed light (IPL, 500–1,200 nm). For example, 595-nm light is emitted by a PDL to an entire area of skin, but is selectively absorbed by hemoglobin. This creates heat within the targeted vessels without affecting surrounding structures. Fractionated devices utilize wavelengths above 1,200 nm and target water as the chromophore. Because water is ubiquitous in skin, selectivity is achieved by the use of a fractionated delivery device which emits columns of varied width and density to the treatment area. These individual columns create “microthermal zones” in the target tissues that generally range from 10% to 70% of the treatment area. With multiple treatment passes a fractionated device can approach 100% ablation of the tissue, so caution is warranted. Both approaches can be beneficial, and the specific uses for each device will be detailed below.

Full-field devices

Many different wavelengths of light are produced by commercially available devices for the treatment of photoaging. Lasers emit monochromatic, coherent light at a single specific wavelength, and this is typically used to target a single chromophore. Conversely, IPL is structurally composed of a flashlamp

which emits polychromatic, noncoherent light composed of many wavelengths, commonly from 500 to 1,200 nm. While lasers are more selective for a given chromophore, IPL is advantageous because it produces light of various wavelengths and thus can target several different chromophores at once. Current devices are coupled with various filters in order to make the output slightly more selective, eliminating all light with a wavelength shorter than the filter threshold. This versatility makes IPL a very useful device for those seeking to use a single device that can treat multiple conditions. On the other hand, the flexibility of IPL devices can also be a handicap if used incorrectly, as the nonspecific output can make outcomes less predictable and therefore result in complications. Consequently, more experience with this device is warranted for more predictable results to be obtained.

Light-based devices generate significant heat during use, which can cause unwanted dyspigmentation, blistering, and scarring via nonspecific bulk heating. To avoid this complication, devices are coupled with a cooling mechanism that either functions by direct contact cooling or a cryogen spray mechanism. In addition to the device cooling, many providers use cold gel or forced air in order to protect the epidermis and prevent unwanted burns or pigmentary changes. In addition to providing epidermal protection, the use of cold gel improves light penetration by reducing the refractive index between the air and the skin.⁵⁹ The duration of cooling is proportional to the depth of the targeted structure, with less cooling used for epidermal targets and longer cooling duration useful when treating deeper dermal structures.⁶⁰

One of the most commonly observed manifestations of photoaging are solar lentigines. These noticeable lesions are the result of chronic ultraviolet light exposure and are often cosmetically unacceptable to patients. The melanin within lentigines has a broad absorption spectrum peaking at 335 nm and steadily decreasing to just beyond 700 nm. As there are no specific peaks, it can be targeted with multiple wavelengths, and most surgeons select a laser with output in the 500 nm range such as KTP (532 nm) or an IPL with filters inclusive of the low 500 nm. The benefit of IPL in the treatment of these benign but unwanted pigmentary lesions is significant and has been well studied.⁶¹ When using appropriate treatment parameters, benign lentigines may be very responsive to therapy, and atypical or resistant lesions should be considered for biopsy to exclude melanocytic lesions such as a nevi or even lentigo maligna.

Benign solar lentigines are composed of melanosomes which accumulate at the base of the epidermis along the rete ridges. These melanosomes serve a protective function in chronically photodamaged skin by aggregating intracellularly above the keratinocyte nucleus. This shields the nuclear DNA from ultraviolet radiation, and is thought to prevent carcinogenesis. During treatment, these melanosomes preferentially absorb photons, are degraded during light conversion to thermal energy, and subsequently aggregate within the epidermis as “microcrusts.”⁶² These crusts are then extruded from the epidermis over the subsequent 7 to 10 days, clinically observed as a coffee-ground like material on the surface of the skin.

The telangiectasias of chronically photodamaged skin can be similarly treated by understanding the absorption spectrum of the hemoglobin within them. Hemoglobin has high relative absorption at 542 nm and 577 nm which can be targeted with either KTP, PDL, or IPL with appropriate filters inclusive of those peaks. According to the theory of selective photothermolysis, the energy pulse duration should be slightly shorter than the thermal relaxation time (TRT) of the target chromophore, which is related to the square of the chromophore size. The relatively small melanosomes of solar lentigines are roughly 0.5 μm , and thus have a TRT of approximately 70 to 250 nanoseconds. These short TRTs are the reason that nanosecond spectrum Q-switched lasers are commonly used for pigmented lesions. Larger telangiectasias often measure 30 to 100 μm , and thus are effectively treated with a pulse duration in the 1 to 20 ms range.⁵⁹ Understanding this difference in chromophore size and TRT is important because it explains the cause of some common complications. When using relatively longer pulse durations in the 10 to 25 ms range typical for targeting vessels, pigmentary complications are more common as this exceeds the TRT of melanosomes and may lead to bulk tissue heating.

In addition to the treatment of vascular and pigmented lesions, over time it has become apparent that there is an unrelated photorejuvenation effect from light-based devices, particularly when using the longer wavelengths emitted in the near infrared spectrum with IPL (800–1,200 nm). In this spectrum, the emitted light targets water as a chromophore, and has been shown to have proliferative effects on tissue fibroblasts. Photodamaged skin is composed of fragmented, thickened collagen fibers, as well as an increased ratio of collagen 3 to collagen 1. Tissue fibroblasts treated with IPL demonstrate

increased production of collagen 1, as well as a decrease in matrix metalloproteinase enzymes responsible for collagen degradation.⁶³

With all light-based treatments, patient selection is essential to success. Selective photothermolysis requires that the tissue target has a unique absorption spectrum relative to the surrounding structures in order to be selective. For example, a Fitzpatrick type I patient with dark solar lentigines would be a relatively good candidate because of the absorption spectrum contrast between the low melanin skin and melanin-laden lentigines: the melanin within the lentigines would readily absorb the photoenergy while leaving the surrounding melanin-poor skin unaffected. Conversely, a tan Fitzpatrick type III patient with the same lentigines would be much more difficult to treat safely because of the increase in baseline epidermal melanin content throughout the skin. In the second scenario, the chromophore is more uniformly distributed throughout the skin, and treatment may lead to unwanted hypopigmentation or burns.

In addition to selecting the appropriate patient for treatment, it is also imperative to evaluate the site of treatment.

Cautions Based on Treatment Site

- Forehead/eyelids: Avoid accidental treatment of eyebrows/eyelashes/hair when using IPL, as this device can be used for laser hair removal with longer pulse durations. At best, the inadvertent treatment of eyebrows results in a temporary loss of hair, and at worst it can lead to permanent decreased hair density.
- Upper lip: Terminal hair density is very high in this area, and with a higher melanin chromophore density there is a higher risk of bulk heating and unintended scar.
- Neck: The skin on the neck is more delicate than that of the face because of the reduced number of follicular and adnexal structures, and decreased fluence is necessary when treating this area to prevent dyspigmentation and scarring.

Observing appropriate clinical endpoints is essential to successful use of lasers and IPL. After the initial pulse with any device, the skin should be assessed for bruising or blistering, both of which can indicate that therapy is too aggressive. When using a KTP laser on pigmented lesions, the appropriate endpoint is superficial greying of the lesion; this should be differentiated from the white color change and bullae seen with overly aggressive treatment. When using PDL the target vessels should turn a slightly purple hue with longer pulse durations (3–10 ms), and purpura is expected when using shorter pulse durations (<3 ms). Finally, the expected endpoint for IPL is nonspecific mild erythema within minutes, which subsequently lasts roughly 48 hours.

The first treatment with each device should be expected to yield the most benefit, as subsequent treatments will have less chromophore to target. This has been demonstrated with multiple devices, but most decisively by Yamashita, et al. with the use of confocal microscopy when treating lentigines with IPL. The readily observed clinical and microscopic decrease in melanin results in diminishing returns with each subsequent session, as the relative amount of residual target chromophore is decreased.⁶² There is still benefit from additional treatments, but patients should be counseled thoroughly in order to have appropriate expectations.

Fractionated lasers

Fractionated lasers have revolutionized the treatment of photoaging.⁶⁴ The first full-field resurfacing lasers had wavelengths in the infrared spectrum, with water as their primary chromophore. As water is present in all tissue, the initial nonfractionated devices were essentially nonselective, resulting in complete ablation of the epidermis in the treatment field. This ablation leads to new collagen formation and the subsequent desired improvement in cosmesis. While this allowed for more dramatic improvement in skin texture, complication rates were significant: treated areas were often eroded and crusted for several weeks and hypo/hyperpigmentation, infection, and scarring were not uncommon.⁶⁵ The introduction of fractionated devices allowed for partial epidermal ablation, and much more rapid epithelialization from adnexal stem cell reservoirs in the untreated skin.

Although the clinical improvement seen with fractionated treatment is less impressive than fully ablative lasers, the significantly faster recovery time and improved safety profile have made these devices much more attractive to both clinicians and patients. While these devices are overall safer, treatment complications may include herpes simplex reactivation, acneiform eruptions, bacterial infections, prolonged erythema, unintended pigment alteration, edema, and scar.

As their name suggests, fractionated lasers affect only a fraction of the treatment field by creating columns of treated tissue surrounded by unaffected tissue. These devices produce very narrow beams (measured in the micrometer range) of laser light of varying width and depth to create “microthermal zones” (MTZ) of tissue coagulation (near infrared), complete ablation (Er:YAG), or a combination of both (CO₂). Most current devices allow for calibration of the percentage of area treated, the laser energy output (which determines depth of penetration), and the number of passes necessary to achieve the desired endpoint.

Of note, the number of passes required to treat a given area is very important to prevent bulk heating. For example, if the treatment density were to be set at 60% and achieved in a single pass of the laser, the intervening “untreated” skin would likely be unintentionally heated, which can lead to unwanted blistering, pigment change, and scar. To avoid this, many devices allow for adjustment of the number of passes needed to reach the target density. Treating 10% of the skin in each pass for a total of 6 passes allows for cooling of the tissue and is less likely to result in unintended side effects. This is particularly important when treating adnexa-heavy areas such as the beard and upper cutaneous lip. While it slightly increases the clinician’s time to segment the treatment into multiple passes, the increase in safety and ability to feather treatment by sweeping the laser in various directions is worth the effort.

Despite sharing the same wavelength, two different devices from different manufacturers are not directly comparable. Beam characteristics vary among devices of the same wavelength, with some devices producing a gaussian output while others produce a “top hat” type output. Additionally, the fractionated density is not directly comparable across devices: some ablative devices consider only the laser column when calculating treatment density, while others include the column as well as the surrounding coagulation

region. It is always important to consult the manufacturer's instructions and to start with conservative parameters until the user gains more experience.

Nonablative fractionated lasers

Fractionated devices have utilized various infrared wavelengths to achieve skin tightening via coagulation alone. The near infrared wavelengths are nonablative in nature, and include devices with output from 1,410 to 1,927 nm. The target chromophore for these devices is water, but the absorption coefficient is not high enough in this range to cause vaporization of tissue. Rather, evaluation of the microthermal zones reveals tissue coagulation, which leads to neocollagenesis. While these devices do not deliver the same improvement in a single treatment when compared to ablative devices, they may be preferable for patients because of the very minimal downtime. Patients can expect several days of edema and erythema as well as a better safety profile.⁶⁶ While a direct comparison is not possible, three to six treatments with a nonablative device may yield similar results to a single ablative treatment.

The initial mainstream fractionated nonablative laser was the 1,550-nm erbium fiber laser. This resulted in objective skin tightening and improvement in dyschromia. The 1,927-nm thulium laser was introduced a few years later in 2009. This wavelength is better absorbed by water, penetrating at most 170 μm into the skin, which correlates with the epidermis and papillary dermis. As may be expected, this yielded significant improvement in superficial pigmentary conditions such as lentigines and melasma.⁶⁷ In addition to superficial pigmentary improvement, several studies have shown reduction in actinic damage and subsequent improvement in skin texture as well.^{68,69}

Ablative fractionated lasers

The current gold standard in laser facial rejuvenation is fractionated ablative laser technology. These devices are able to produce results nearly as dramatic as traditional fully ablative lasers but with significantly faster healing. The two main wavelengths from this category are the erbium: yttrium aluminum garnet (Er:YAG, 2,940 nm) and carbon dioxide (CO_2 , 10,600 nm) lasers.

These devices have different properties based on their relative absorption by water. The Er:YAG is absorbed 16 times more effectively than the CO_2 ,

and this leads to immediate water vaporization. The instantaneous vaporization causes complete ablation in the MTZ without the ability of the heat to travel beyond the laser column. Because there is no coagulation, bleeding is readily observed from the MTZs during treatment. The CO₂ laser is not absorbed as well as the Er:YAG. Because of the relatively slower vaporization of water, some of the residual heat from the laser may spread into the tissue surrounding the MTZ, creating a peripheral layer of coagulation. This is observed clinically as reduced bleeding during treatment. In addition to the difference in hemostasis during treatment, a CO₂ laser leads to longer lasting erythema post procedure.⁷⁰ This is thought to be because of the heating of the tissue between the MTZs, which are ablated channels.

Studies have shown that both Er:YAG and CO₂ devices can improve skin wrinkling, pigmentation, atrophy, texture, and tone. The superiority of one wavelength over the other has not yet been definitely shown,⁷¹ though some experts believe that the longer erythema seen with the CO₂ is a sign of more prolonged neocollagenesis, and therefore improved long-term cosmesis.⁷²

CONCLUSIONS

Facial rejuvenation is a common presenting patient complaint. For global textural improvement, both chemical peels and laser- and light-based treatments are excellent options. Patients and surgeons should weigh the relative benefits and risks of each procedure, as there is generally an inverse relationship between treatment efficacy and the risk of dyspigmentation, as well as patient downtime.

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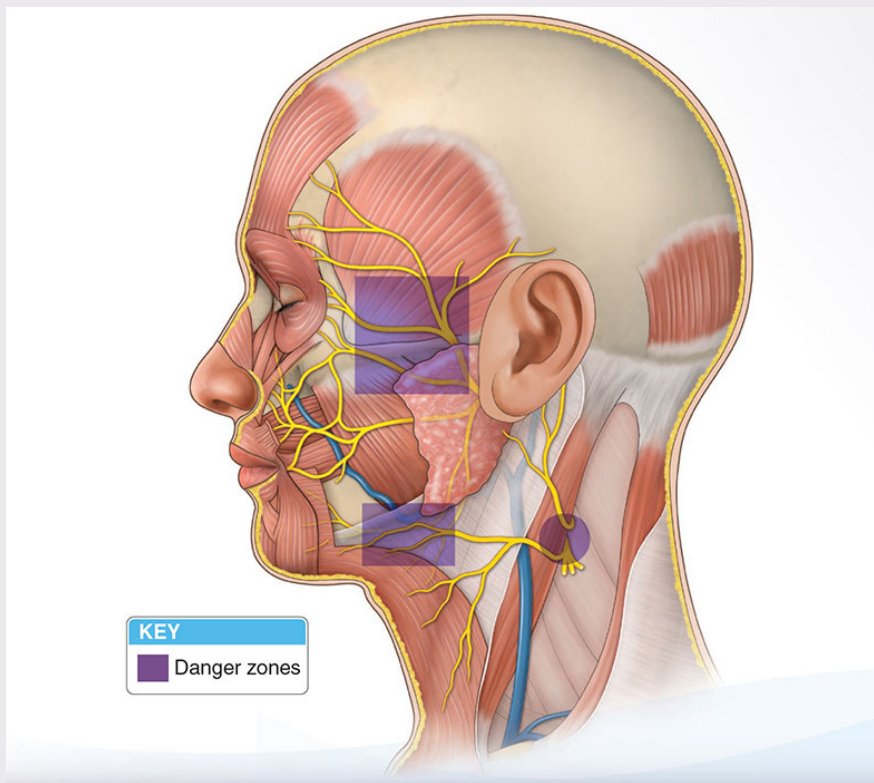
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CHAPTER 79 Approaches to Neck Rejuvenation

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SUMMARY

- Restoration of a youthful neckline is arguably one of the most critical aspects of achieving overall aesthetic balance.
- Multiple intrinsic and extrinsic factors including genetics, photodamage and gravity contribute to aging in the neck.
- Combination treatments may ultimately yield better outcomes for many patients.

Beginner Pearls



- Loss of definition along the jaw—an invariable effect of changing anatomy over time—may be improved via the Nefertiti Lift.
- Microbotox is another useful technique for improving the overall appearance of the neck.

Expert Tips



- For optimal restoration and multilevel cosmetic revitalization, dilute fillers are frequently combined with light- or energy-based modalities that stimulate tissue contraction and subsequent tightening.
- Neck liposuction using tumescent anesthesia will dramatically improve the cervicomenal angle and create a pleasing contour.

Don't Forget!



- Combination treatments may offer the best solution for neck rejuvenation.
- Plication sutures may be very useful to maximize and maintain lift.

Pitfalls and Cautions



- Laser resurfacing on the neck should be performed with caution due to the lack of pilosebaceous units and the attendant increased risk of scarring.
- There have been reports of scarring even with a fractional CO₂ laser.

Patient Education Points



- There is typically a tradeoff between the amount of downtime associated with a procedure and its efficacy.
- Patients should understand that many treatments used for neck rejuvenation will need to be repeated on a regular basis.

- Patients should ideally see neck rejuvenation as one component of a global approach to facial rejuvenation.

CHAPTER 79 Approaches to Neck Rejuvenation

INTRODUCTION

Treatment of the aging neck presents a special challenge to the aesthetic dermatologic surgeon. Thin, fragile skin, the small number of cutaneous adnexal and pilosebaceous units, variable accumulation of submental fat, and hypertrophied and separated platysmal bands require careful planning and a comprehensive approach.¹ Restoration of the youthful neckline is arguably one of the most critical aspects of achieving overall aesthetic balance, particularly as the increasing popularity of procedures in facial aesthetics gives rise to greater disparity between the smooth contours of the treated face and a neck that appears skeletonized and distinctly aged.

NECK ANATOMY

While the overall anatomy of the neck is complex, the superficial anatomy most commonly addressed by cosmetic procedures includes the skin, subcutaneous fat, superficial cervical fascial system, and the platysma. Neck skin is very thin, only slightly thicker than upper eyelid skin. Subcutaneous fat distribution is variable, though it is thinly layered over the platysmal muscle, but tends to accumulate in the submentum. There is also a deeper submental fat pad.

The platysma is a thin shield-like muscle. It originates on pectoralis fascia. Its anterior border is the risorius muscle at the oral commissure. Posteriorly, it inserts into the SMAS. The platysma is innervated by the cervical branch of the facial nerve. Its vascular supply stems from branches

of the facial artery. It is not clear what the function of the platysma is. In animals such as horses, contraction of the platysma helps to ward off insects. In humans, it does depress the corners of the mouth, and acts as a stabilizing force.

The sternocleidomastoid (SCM) is a major muscle of the neck, but generally it is not manipulated cosmetically. However, the greater auricular nerve (C2, C3) travels superficial to the SCM, and is very superficial as it terminates inferior to the auricle around the lobule. It is susceptible to injury during a surgical neck lift. The spinal accessory nerve (CN XI) lies in the posterior triangle, and though less likely to be compromised in many superficial neck rejuvenation procedures, is also susceptible to injury during a neck lift. Anteriorly, the marginal mandibular branch of the facial nerve courses inferior to the angle of the mandible and then runs in the superficial layer of the deep cervical fascia just superficial to the submandibular gland and the anterior facial vein. It continues its course over the mandible where the nerve is very superficial and terminates lateral to the anterior commissure. In a small percentage of individuals, its thin rami anastomose with those of the buccal branch of the facial nerve. Extreme care must be taken in these areas.

The youthful neck

The youthful neck is characterized by a uniform skin tone, a smooth texture and contour, a tautness of the skin and defined fullness that is in harmony with the face. The neck is bounded by a sharp jawline superiorly and inferiorly, a smooth transition at the sternal notch. Structurally, the youthful neck including the submentum is distinguished by a cervicomental angle of between 105 and 120 degrees and a submental SCM angle of 90 degrees. Male necks typically are more muscular with a greater circumference with a more defined and larger submentum than the female. The female neck generally has smoother skin. Michelangelo's David epitomizes the youthful neck.

The aged neck

Multiple intrinsic and extrinsic factors including genetics, photodamage, and gravity contribute to aging in the neck. A decrease in collagen and elasticity

throughout the face and neck leads to loss of subcutaneous support, and result in sagging and ptotic submandibular glands. Skin becomes lax and fat accumulates in the submental region, softening the mandibular contour and creating jowls.² Regular twisting and swivelling motions and contraction of the platysma muscle result in prominent banding and horizontal rhytides, while chronic exposure to UV radiation wreaks havoc on skin texture and pigmentation and accelerates the course of natural aging.³ Platysmal bands—longitudinal cords in the neck midline—appear. There is most likely a dual etiology for this phenomenon—genetics and anterior platysmal hypertrophy. It is estimated that 39% of the population has undecussated (separated) midline platysmal muscle fibers. These are hidden in youth, but as fat diminishes with age, they become more apparent. Relaxation of surrounding tissue also contributes to this separation. Decades of vigorous muscle contraction result in hypertrophy in some individuals. Clinically, this contributes to the “turkey gobbler” neck.

Treatment philosophy

When evaluating the neck, it is paramount to evaluate all layers including skin, fat and muscle, and to accurately diagnose the pathophysiology, which will lead to the appropriate treatments. It is uncommon that neck rejuvenation can be maximized with one type of treatment. During the consultation, it is important to examine the patient from all angles. When examining the neck, it is important to have the patient bite down and smile, since this will help identify platysmal banding. It is helpful to take photos, and then show the patient. Many times, a patient will not realize the extent of their aged neck since they look at their neck from the frontal view. When developing a plan, it is important to remember that if liposuction is an appropriate treatment for submental fat, then it may unmask platysmal bands which will also need to be treated. It is also important to determine if the patient has a prominent hyoid bone which can create the effect of a less acute cervicomental angle, and standard aesthetic procedures will not be appropriate. It is also important to understand that surgical neck procedures will not improve jowling—unlike a full facelift. Aesthetic restoration of the neck aims to improve laxity, skin quality, and texture, reduce wrinkling and the appearance of prominent bands, and defines the cervicomental angle formed by the horizontal plane of the submental region and the vertical plane of the neck. Although surgery remains

the gold standard and often provides the best outcomes, nonsurgical options are in high demand. Because they target individual aspects of aging, noninvasive or minimally invasive alternatives are frequently used in combination to achieve optimal results.

Cosmeceuticals

Topical formulations are helpful components of an ongoing, preventative, or restorative skin-care regimen, although care must be taken: the thin, crepey skin of the neck is delicate and prone to irritation or injury that can be slow to heal. There are a staggering number of day and night formulations on the market that contain additives designed to improve skin texture and appearance: moisturizing agents to smooth and hydrate, antioxidants (e.g., vitamins C and E) to reduce oxidative stress and free-radical damage, and topical growth factors and peptides to boost collagen and elastin production for improvements in laxity and fine rhytides.^{4,5} Retinoid acid—the active form of vitamin A and considered the gold standard treatment for photodamage—induces neocollagenesis for marked improvement in elasticity, fine lines, and hyperpigmentation, but is more likely to cause significant irritation in the neck and should be used cautiously and at low strength. Nonprescription retinol—the weaker version—may produce similar efficacy with better tolerability.⁶

Neurotoxin

Botulinum toxin (BTX) is the most widely used treatment for platysmal bands and dynamic rhytides.^{7–9} Deep intradermal injections using small doses placed equidistantly across multiple sites along the length of each vertical band produces a gentle anterior neck lift and consistently softens the prominence of the cords on animation. Injecting the bands may also diminish horizontal “necklace” lines in some patients, but this is inconsistent. Guidelines recommend a total dose of 30 to 60 U onabotulinumtoxinA divided among all injection points, as determined by patient assessment and clinical experience.¹⁰

Loss of definition along the jaw—an invariable effect of changing anatomy over time—may be improved via the so-called Nefertiti Lift, in

which small doses of BTX (15 U onabotulinumtoxinA per side) are injected in multiple sites under the mandible and intradermally into the upper half of the actively contracting posterior platysmal band to sharpen the contours of the jaw and raise the corners of the mouth.^{10,11}

Not everyone is a good candidate for neurotoxin injections in the neck; some precautions are advised. BTX works best on younger patients with good skin elasticity or postoperatively for residual bands.¹² In individuals with extensive cutaneous laxity, poor cervical skin elasticity, and flaccid platysmal cords, injections can worsen the appearance of the neck. Large doses—in excess of 50 U onabotulinumtoxinA in one session—can produce weakness in the neck flexors and dysphagia and should be avoided.^{9,11}

Alternatively, microbotox—the injection of multiple microdroplets of dilute onabotulinumtoxinA into the dermis or the interface between the dermis and superficial layer of facial muscles—is a simple alternative for patients with early signs of aging in the neck.¹³ Microinjections target the superficial fibers under the surface of the skin, decreasing sweat and sebaceous gland activity for an intradermal effect. In the neck, tiny blebs injected as superficially as possible across the entire sweep of the platysma muscle improves skin texture, color, and smoothness, reduces the appearance of horizontal necklace lines and vertical banding, and creates a lifting effect of the jowls and jawline for better cervicomental contouring.¹³

Fillers

Residual wrinkling and skin laxity in the neck can be improved with soft-tissue fillers, such as hyaluronic acid (HA), calcium hydroxylapatite (CaHA), or poly-L-lactic acid (PLLA), especially when used in combination with other aesthetic procedures. Fillers can be used in neck rejuvenation to soften necklace lines, redefine the jawline which can improve the submental contour, and intradermal injection for improvement of skin quality. Although the neck was once considered unsuitable for particulate fillers due to the scarcity of subcutaneous tissue and consequent risk of complications,^{14,15} increasing the dilution ratios raises the safety profile and provides improvement in texture, skin thickness, and wrinkles.^{1,16} For optimal restoration and multilevel cosmetic revitalization, fillers are frequently

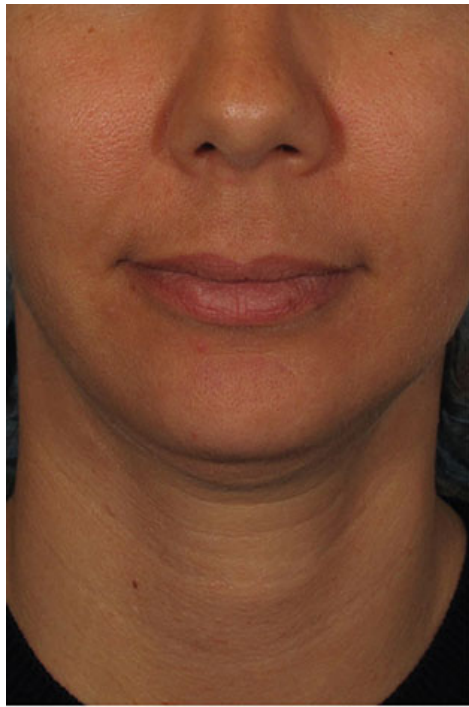
combined with light- or energy-based modalities that stimulate tissue contraction and subsequent tightening.^{3,17,18}

Cryolipolysis

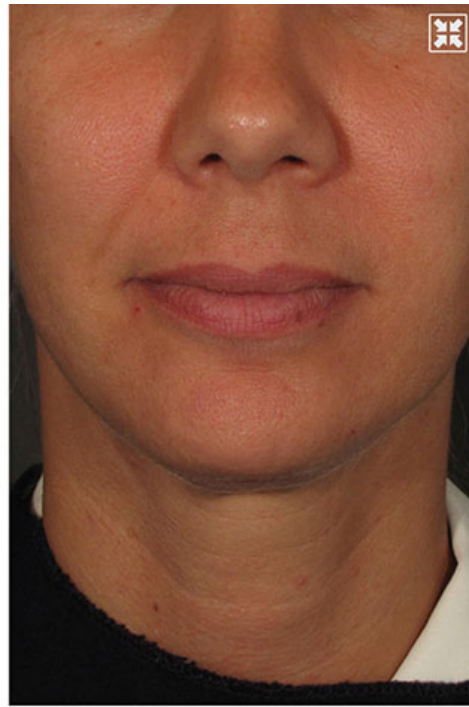
Submental fat accumulation contributes to an obtuse cervicomental angle and can age a patient or make them appear overweight. Widely used in all areas of the body, cryolipolysis selectively reduces fat cells with controlled, localized cooling and is a promising procedure for nonsurgical fat reduction and may be a viable alternative to liposuction.^{19,20} Although there are limited data for use of cryolipolysis in the neck, a pivotal study of 60 patients demonstrated visible improvements in the neck contour and generated high patient satisfaction, with a mean fat layer reduction of 2 mm.²¹ Cryolipolysis of submental fat may require multiple sessions to achieve the desired effect.³

Sodium deoxycholate

Recently approved by the Food and Drug Administration (FDA), deoxycholic acid injection (Kybella) is the first minimally invasive, nonsurgical treatment for the reduction of submental fullness. Subcutaneous injection of deoxycholic acid into submental fat results in adipocyte lysis, leading to significant, localized fat reduction.^{22–24} Four phase 3 trials have demonstrated significant clinical efficacy^{25–28} with only minimal side effects, such as pain, swelling, bruising, and erythema. Although increased skin laxity is normally a concern after removal of targeted subcutaneous fat, secondary or adjunctive procedures for skin tightening have not been routinely required after injection, suggesting that deoxycholic acid may induce concomitant skin retraction (Fig. 79-1).²⁹



A



B



C



D

Figure 79-1. Sodium Deoxycholate for Submental Contouring. (A/C) A 41-year-old woman before treatment. (B/D) Six months after two treatments with sodium deoxycholate for submental fullness (total dose 6 mL).

Microneedling

Percutaneous collagen induction (PCI) therapy, or collagen induction therapy, is a minimally invasive procedure involving the physical trauma of needle penetration to promote regeneration.³⁰ Microneedling devices equipped with fine needles applied to the skin create controlled-depth skin injury and are believed to induce the tissue-repair cascade of inflammation, proliferation, and remodeling for continued improvements in overall skin quality, thickness, and superficial wrinkling over a period of several months.³¹ Histologic examination of skin treated over multiple sessions has shown significant increases in collagen deposition and epidermal thickness at 6 months.^{32–35} There is a proliferation of devices and systems on the market with needles ranging in length from 0.5 to 3 mm; increasing needle depth demonstrates improved results but is associated with longer downtime and greater swelling, bruising, and bleeding.³³ Because treatment does not ablate the epidermis or create open wounds, PCI therapy is slowly gaining ground as treatment for photoaged skin, particularly in areas considered unsuitable for resurfacing with lasers or chemical peels.^{25,32} The procedure is well tolerated, with minimal downtime, although multiple sessions are required to produce a visible response. The evidence to guide best practices in the use of microneedling for neck rejuvenation is scant.

Energy devices

Though one must proceed carefully with laser resurfacing due to the lack of pilosebaceous units and the increased risk of scarring, short-pulsed carbon dioxide laser is likely safe and effective for the skin of the neck. It can be used to improve mottled pigmentation, texture, mild rhytides and the necklace line. One retrospective study demonstrated a 39% reduction in rhytides in 308 subjects without any pigmentation or scarring.³⁶ The erbium laser on lower depth settings was also found to be safe and effective for the neck. The advent of nonablative and ablative fractional laser resurfacing has also created more options for neck skin rejuvenation. Nonablative fractional laser has minimal downtime, but requires multiple treatments to be effective. Fractional carbon dioxide can be used, but with low-energy settings and one

pass. There have been reports of scarring with the fractional carbon dioxide¹⁹ laser and an increased risk of hypopigmentation.

For moderate lifting and tightening with minimal down time, high intensity–focused ultrasound can be moderately effective for the appropriate patient. This technology penetrates deeper into the skin and remodels collagen and possibly the SMAS. It improves jowls and will improve the cervicomental angle. Though it is tempting to treat the neck only, there will be better results if the lower face is also treated, since this will provide additional lift, tightening, and harmony. High-intensity ultrasound can be painful. One author (HBG) will perform micro field blocks with 1% lidocaine and 1/100,00 epinephrine, wait for 15 to 20 minutes so there is no swelling and the liquid has been absorbed so it does not modify the effectiveness of the treatment. Patients are uniformly comfortable with this technique. In general, there is no downtime with this procedure, and results may require 6 to 12 months. Using multiple treatments, this modality can also be used to reduce neck circumference.³⁷

Fractional radiofrequency needling is another novel energy device that can improve neck contour. The RF generates heat transmitted fractionally by small needles into the dermis. In studies, these devices have been shown to lift, tighten, smooth, and volumize. In one study, fractional RF was measured to having the equivalent effectiveness of one-third of rhytidectomy.^{38,39} For the neck, some of these RF microneedling devices have modified the angle and depth of their needles for deeper penetration. This has resulted in fat reduction, and improved the cervicomental angle in one unpublished study. This modality will result in downtime. There can be extensive swelling of the neck that may last 1 week. Similar to ultrasound, optimal results may require 6 to 12 months. Another RF-based technology—thermistor-regulated—has been shown to significantly increase neck tightening with minimal recovery time (Fig. 79-2).



Figure 79-2. Profound RF. (A) Before. (B) Three months post submental Profound using the SubQ handpiece.

Liposuction

For patients with excess submental fat, neck liposuction using tumescent anesthesia will dramatically improve the cervicomental angle and create a pleasing contour. The principles of body liposuction apply to neck liposuction with some minor modifications. Because of the greater vascularity of the neck, a tumescent solution of 0.1% lidocaine with 1/500,000 epinephrine is generally used. Smaller cannulas, mostly 14- to 16-gauge cannulas are more appropriate, though 12-gauge cannulas may be used with caution, and may be more effective in men who have slightly more fibrotic fat.

The patient should be placed in a supine position with a towel roll or pillow under his or her neck to give better exposure to the submentum and neck. For patient comfort, oral sedation can be administered an hour prior to the procedure. Using either an infiltrating cannula, or a 20-gauge spinal needle, the anesthesia is infiltrated. Stab incisions should be made in the submental crease and bilateral infraauricular below the angle of the mandible.

Using a 16-gauge cannula, and grasping fat with the “smart hand,” the cannula is inserted into the subcutaneous plane. The strokes should be in a crisscrossing pattern. This is followed by the 14-gauge cannula in a similar pattern, and gently sweeping up to mandible. The submentum and the neck are then approached in a similar fashion from the lateral infraauricular stab incisions. A thin layer of fat should be maintained to reduce the risk of dimpling. A compression garment is worn. While there will be bruising and swelling, recovery time is generally 3 to 4 days. It is felt that neck liposuction works by not only the removal of fat, but by “gently” traumatizing the dermis and the platysma muscle, which will result in contraction of the skin. Anecdotally, there may be more skin tightening in female patients, and in one study, patients over the age of 40 did not experience less skin tightening after liposuction.⁹ Final results may take up to 6 months.

True contraindications for neck liposuction are few, but include patients who are on blood thinners. Complications include hematoma, infection, dimpling, asymmetry, numbness, and motor nerve injury. The marginal mandibular nerve is at risk, particularly in individuals with submental fullness but a thin neck. Particular caution needs to be paid when sweeping close to the mandible and in the region of the submandibular gland which can also be traumatized and cause postoperative swelling. If the marginal mandibular nerve is injured, it may result in a palsy and asymmetric smile for 6 to 8 weeks. Fortunately, since the nerve will be bruised and not severed with a blunt cannula, the injury is temporary, but can cause significant stress to the patient. Aggressive liposuction of the neck can also cause a pseudopalsy of the marginal mandibular nerve which is due to trauma to the cervical branches of the facial nerve. This is also temporary and generally not as severe as a true injury to the marginal mandibular nerve. Aggressive submental liposuction can also result in a concavity which is not aesthetically pleasing (Fig. 79-3).



Figure 79-3. Neck liposuction. (A) Before. (B) Three months postprocedure.

Sutures

Suture lifts have gained popularity over the past 15 years. In theory, they are appealing because this is a minimally invasive procedure that can produce a significant, predictable lift that is tailored to the patient's anatomy. Suture lifts of the midface have been popularized by Sasaki and Keller. For lax facial and neck skin, Sulamanidze introduced barbed sutures.⁴⁰ These sutures went through several iterations in order to improve longevity. These sutures had bidirectional barbs and were nonabsorbable. Though it was an uncomplicated office procedure that produced immediate results with minimal downtime, the barbs didn't maintain the lift for more than 12 months. In addition, there was an unacceptable rate of migration. The sutures evolved to a combination of absorbable PLLA cones with a nonabsorbable suture. The cones were felt to better lock into the dermis, and then create fibrosis and possibly collagen stimulation, while the primary nonabsorbable component would increase the longevity.⁴¹ The latest innovation, which has been studied in Europe, is completely absorbable bidirectional suture cones; these were introduced in the United States in 2016. These sutures only produce a mild lift, but may increase volume since they are biostimulatory.

Surgery

Surgery for the neck consists of tightening and lifting lax skin and correcting platysmal bands. Surgery is still the gold standard for these two major

elements of neck aging. A formal neck lift is essentially the posterior aspect of a lower facelift. The results are predictable and reproducible. It can be performed in the office setting with tumescent anesthesia. In most patients, this excisional surgery is combined with liposuction.

Platysmaplasty

In many patients, the platysmaplasty is performed in conjunction with the neck lift. However, in a subset of patients who do not have lax neck skin, it can be performed as a standalone procedure. Its purpose is to correct the platysmal bands, and recreate the flat shield-like structure of this superficial muscle. Over the decades, there have been different methods to revise the bands. Unfortunately, there does not appear to be method that consistently, completely, and permanently smoothes these cords. The corset platysmaplasty described by Feldman involves suturing the two bands together inferiorly, and then superiorly in two rows.⁴² This is the classic method, but can be time consuming and increases the risk of bleeding and bruising. Other surgeons have recommended only lateral plication of the platysma, which will stretch the platysma and flatten the midline bands. However, this truly does not address platysmal hypertrophy. Other surgeons have recommended a transverse myotomy, though this may lead to stump formation and asymmetry. The method that one of the authors (HBG) utilizes is to approximate the platysma in the midline with four interrupted prolene sutures with lateral plication sutures.

More elaborate minimally invasive suture-based solutions for the platysma have been reported. Giampapa described an effective interlocking suture suspension lift for both the platysma and lax skin that demonstrated some effectiveness 13 years following the procedure.^{43,44} More recently, Mueller has created a percutaneous “trampoline” platysmaplasty and reported on his experience with 105 patients who maintained satisfactory results with a 33-month follow up.⁴⁵ An accompanying cadaver study confirmed the tensile strength of the sutures. In addition to correcting platysmal banding, ptotic submandibular glands contribute to blunting of the cervicomental angle and a youthful neck. A suture sling suspension using either goretex or prolene can support the submandibular glands and the superior portion of a ptotic platysma. Small incisions on the neck posterior to the earlobe are made. The suture is then secured and fed through a 16-gauge liposuction cannula through the midline and to the other superior neck

incision and secured. Multiple sutures create a hammock effect. The benefit of using goretex sutures is that they have a greater width than prolene, and theoretically could be tightened over time through small surgical procedures.

Surgical neck lift

The surgical neck lift as mentioned above can be combined with neck liposuction and platysmaplasty depending on the aging characteristics of the patient's neck. Essentially, a neck lift is a lower facelift without the anterior aspect. The goal of the neck lift is to significantly improve the contour of the neck, including the submentum, by lifting and tightening. This procedure can be performed with tumescent anesthesia and oral sedation. The incision starts at the anterior portion of the ear lobule, continues posterior-superior along the postauricular sulcus to the height of the external auditory canal, and then courses posteriorly 5 to 6 cm into the scalp. The flap is undermined using a combination of Mayo, Gorny, and Baby Metzenbaum Scissors. If liposuction has been performed submentally, then it is also performed laterally where the flap has been incised. The neck is completely undermined below the subcutaneous layer. With severe actinically damaged skin, a fair amount of force may be needed given internal fibrosis, but care must be taken not to buttonhole this thin skin. When undermining the skin, scissor tips should be up, and care should be taken on the lateral neck where the external jugular vein is susceptible. The undermining needs to be particularly superficial near the great auricular nerve, along the mandible, and near the submandibular gland (Fig. 79-4).

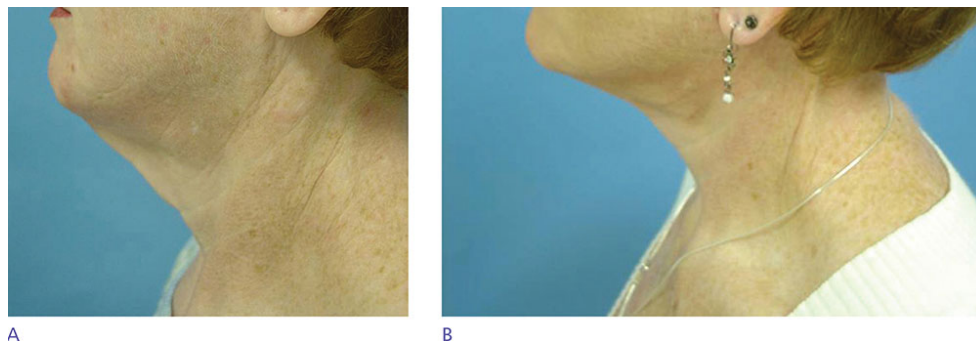


Figure 79-4. Surgical neck lift. (A) Before. (B) Three months postprocedure.

Plication sutures can be absorbable or nonabsorbable, or a combination. Plication should be in a vertical direction. Borrowing from Knize, one author

(HBG) will perform two sets of plication sutures: one set posterior, one set more anterior in order to maximize and maintain lift. The excess skin is then trimmed, allowing for minimal tension. The edges are sutured in two layers, and in most cases, a posterior dog ear will have to be removed. As with the other neck procedures, a compression garment is worn in the postoperative period.

Combination procedures

While surgically based procedures are effective, results can be maximized by combining these approaches with energy- based devices. Following liposuction, high-intensity ultrasound, RF needling or thermistor-regulated radiofrequency technology can be performed on the neck to aid in further contraction of the skin.

Recently, the synergistic effect of combination botulinum toxin injections (using both a microbotox approach and a Nefertiti lift) and sodium deoxycholate injections has been described.^{9,13,46–48} The Bellatox technique led to significant aesthetic improvement after a single treatment, though further studies are needed. Ultimately, complete rejuvenation of the neck is rewarding and requires many different devices and techniques in the dermatologic surgeon's armamentarium (Figs. 79-5 and 79-6).



Figure 79-5. Combination treatment with high intensity–focused ultrasound, onabotulinum toxin A, and sodium deoxycholate. (A) A 58-year-old woman before treatment. (B) Three months after treatment with high intensity–focused ultrasound to the lower face and neck and 60 units of onabotulinum toxin A to the platysma. (C) Four months after previous treatment, no additional intervention. (D) Three months after a single treatment with sodium deoxycholate for submental contouring (4 mL); note improvement in submental region and worsening of platysmal bands as onabotulinum toxin is no longer active.



Figure 79-6. Combination treatment with intense pulsed light and nonablative fractional laser. (A) A 49-year-old woman before treatment. (B) After a single treatment of intense pulsed light and 1,927 nm fractional laser.

CONCLUSIONS

The neck is a critical cosmetic area that has historically been overlooked by aesthetic dermatologic surgeons. As patients increasingly expect rejuvenation of not just the face, but the neck, hands, and other areas as well, neck rejuvenation is increasingly becoming a focus of patient concern. Indeed, perhaps related in part to the new availability of minimally invasive approaches to neck rejuvenation, a significant proportion of patients are now interested in such procedures.

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CHAPTER 80 Approaches to Hand Rejuvenation

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SUMMARY

- As many patients seek facial cosmetic procedures, a discrepancy forms between the rejuvenated look of their face and the aged appearance of their hands.
- Hand rejuvenation addresses both surface changes and volume loss, and combination multimodality approaches may be best.

Beginner Tips



- A thorough understanding of hand anatomy is a prerequisite for procedural intervention.
- IPL and lasers are highly effective at improving surface changes on the hands.
- When using CaHA fillers, the scrape skin threading technique may help to avoid overly deep product placement.

Expert Tips



- If nodule formation occurs after filler injections: antibiotics -> hyaluronidase/ILK -> excision.
- Overcorrect when performing autologous fat transfer.
- Consider sclerotherapy if volumization does not solve vein prominence.

Don't Forget!



- Sclerotherapy and autologous fat transfer should be performed separately.
- Vein treatments should be performed at least 1 month prior to other procedures.

Pitfalls and Cautions



- When performing chemical peels on the hand, it is important to remember that treatments should be limited to superficial and medium depth peels because of the risk of impaired wound healing.
- Since the dorsal hand skin is thinner, has decreased vascularity, and fewer pilosebaceous units than the face, the fluence, density, and number of passes should generally be reduced to minimize recovery time.

Patient Education Points



- Patients should understand that they will likely require multiple treatments.
- Remember the 5–5–5 rule after filler injection: massage for 5 minutes at a time, 5 times per day, for a total of 5 days.

- As always, appropriate patient selection and assuring adequate motivation are of vital importance.

CHAPTER 80 Approaches to Hand Rejuvenation

INTRODUCTION

The face, neck, and hands are not only the most visible parts of the human body, but are also the areas most susceptible to environmental factors which accelerate the aging process. As many patients seek facial cosmetic procedures, a discrepancy forms between the rejuvenated look of their face and the aged appearance of their hands. Therefore, both physicians and patients have become more aware of the need to treat the hands.

AGING OF THE HAND

Aside from the face and neck, the hands are the most exposed part of the human body, and are therefore especially susceptible to environmental factors that are implicated in the aging process.¹⁻³ The young hand has a supple, smooth, and uniformly pigmented epidermis with excellent elastic recoil. The skin is relatively free of rhytides with the exception of flexion creases over the proximal and distal interphalangeal joints. The telltale signs of the aging process typically become discernible in the fourth decade of life.⁴

Ultraviolet radiation contributes significantly to accelerated photoaging, which presents as solar lentigines, solar purpura, actinic keratoses, seborrheic keratoses, telangiectasias, and guttate hypomelanosis ([Table 80-](#)

1). Chronic irritation from common household and workplace chemicals also contributes to the aged appearance of the hand. ¹

Table 80-1. Signs of Aging

Extrinsic Aging	Intrinsic Aging
Solar lentigines	Rhytides
Telangiectasias	Dermal atrophy
Solar purpura	Fat atrophy
Guttate hypomelanosis	Visibility of tendon color
Actinic keratoses	Prominent and tortuous veins
Seborrheic keratoses	Visible bony contour

Another component of the aging hand is soft- tissue atrophy stemming from collagen depletion, epidermal thinning, dehydration, and volume loss of the intrinsic muscles of the hand and subcutaneous fat.⁴ The skin of the dorsal hand thins from 1.2 mm at the age of 25 years to 0.75 mm at the age of 70 years, reflecting a near 40% reduction in thickness.⁴ Furthermore, in contrast to the palmar skin, which adheres to the underlying fascia, the dorsal skin becomes mobile and distensible. This leads to skin laxity, dorsal hand skin wrinkling, greater visibility of the extensor tendons, and greater tortuosity and blue hue of subcutaneous veins.

APPROACH TO HAND REJUVENATION

When examining the hand, it is important to consider the different layers that contribute to the aged appearance of the skin. First, looking at the epidermis and dermis, one should note the presence of superficial rhytides, solar lentigines, telangiectasias, and keratoses. Light-based devices or chemical peels that target the epidermis and dermis will most effectively treat these changes.

Next, the physician should note the amount of volume loss contributing to skin laxity and the visibility of veins and tendons in the dorsal hand. Adding volume to the dorsal hand, via filler or fat grafting, will best mask the

prominence of these changes. Alternatively, the veins themselves can be selectively targeted through sclerotherapy, endovenous laser ablation, or phlebectomy.

Many patients benefit from a multimodality approach. Some physicians perform epidermal and dermal treatments prior to filling of the subcutaneous tissue, theorizing that energy from light-based treatments may lead to degradation of the filler.⁵ This theory has never been supported, and a study by Goldman et al. failed to show any difference in wrinkle severity or global improvement scores in 36 patients treated with hyaluronic acid (HA) filler alone or filler followed by nonablative laser, intense pulsed light (IPL), or radiofrequency (RF).⁶ The only procedures that should always be performed separately are vein treatments such as sclerotherapy and endovenous laser ablation, because of their more complicated postoperative management regimens. Vein treatments should be performed at least 1 month prior to other procedures.

During the pretreatment consultation, the aesthetic goals, expectations, downtime, and possible adverse events of each procedure need to be discussed. The physician should inquire about the patient's usual scope of hand activity, as temporary swelling and dressings may interfere with function. Baseline photographs should be taken with the patient's hands relaxed on a flat surface to capture the appearance of prominent hand veins at rest that commonly disappear when the hand is positioned upright. Additionally, the patient should be educated about the regular use of sun protection and possibly topical retinoids and other cosmeceuticals to potentially better maintain their results.

HAND ANATOMY

The hand fulfills multiple purposes, including sensation, movement, and communication.⁷ It is able to achieve these functions via a complex network of bones, muscles, nerves, ligaments, tendons, arteries and veins. When performing hand rejuvenation procedures, one should be familiar with the relevant anatomy of the dorsal hand.

The external anatomy of the hand is pictured in [Figure 80-1](#). In the anatomic position, palmar (volar) refers to the anterior surface of the hands,

while dorsal refers to the posterior surface of the hand. In order to indicate laterality, most physicians use the terms ulnar and radial.



Figure 80-1. Dorsal hand arterial supply.

The median, radial, and ulnar nerves supply both the motor and sensory innervation to the hand and digits.⁸ The radial nerve supplies the sensory innervation to the radial dorsal hand, and the ulnar nerve to the ulnar dorsal hand (Fig. 80-2). The blood supply of the hand originates from the radial and ulnar artery.⁹ The palmar hand contains the superficial and deep palmar arteries, which give off various digital arteries. In the dorsal hand, branches of the radial and ulnar artery form the dorsal carpal arch, which is located within the dorsal wrist below the thick fascia of the extensor retinaculum.

From the dorsal carpal arch come the dorsal metacarpal arteries, which travel in close proximity to the muscles and bones of the dorsal hand. Eventually dorsal digital arteries branch from the dorsal metacarpal arteries.



Figure 80-2. Sensory innervation of the hand.

There are three venous systems in the hand: the superficial palmar veins, deep palmar veins, and dorsal venous arch.¹⁰ Valves within these veins direct most of the blood flow to the dorsal vein, which then courses into the basilic vein (ulnar side) and cephalic vein (radial side). Because of various communications and redundancy between these systems, obliteration of the dorsal hand veins does not impair venous drainage.⁴

In the anatomic snuffbox, the radial artery, cephalic vein, and superficial branch of the radial nerve sit above the scaphoid and trapezium bones (Fig. 80-1). Filler or sclerotherapy injections into this area should be avoided because of the risk of canalizing or injuring these important neurovascular structures.

The skin of the dorsal hand is thin and has few appendages, resulting in inferior wound healing compared to other parts of the body. It is also more loosely connected to the underlying structures. Lefebvre-Villardabo et al. conducted an in-depth review of the anatomy of the dorsal hands through

cadaveric dissection and duplex ultrasound, studying live subjects ranging in age from 25 to 72.¹¹ They found that the dorsal hand is composed of the epidermis, followed by the dermis, sponge-like fascial layer, tendons, deep fascia, and bones with their interosseous muscles (Fig. 80-3). The dermis measured 0.2 to 0.9 mm, the fascial plane 0.3 to 2.2 mm, and the tendon layer 0.7 to 1.7 mm. They found an intricate pattern of veins residing at all levels of the fascial layer. It is therefore important to keep in mind that the bevel of a needle is 0.75 mm in length.

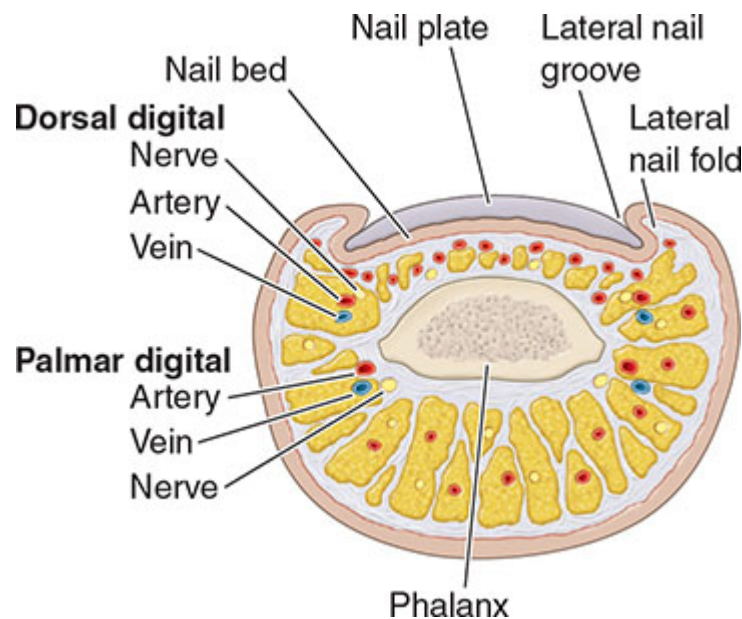


Figure 80-3. Cross-sectional anatomy of the digit.

Another anatomical study by Bidic et al. used histologic analysis, duplex ultrasonography, and lead oxide evaluation to examine the dorsal hand.¹² They found three separate fat compartments and fascial layers. From superficial to deep, the authors observed the epidermis, dermis, dorsal superficial lamina, dorsal superficial fascia, dorsal intermediate lamina, dorsal intermediate fascia, dorsal deep lamina, dorsal deep fascia, followed by muscles and tendons. Since veins were found in the dorsal intermediate lamina and extensor tendons in the dorsal deep lamina, the authors concluded the safest plane of injection is the dorsal superficial lamina.

VOLUME RESTORATION

Restoration of volume in the dorsal hand can greatly reduce the appearance of skin laxity as well as the visibility of veins, tendons, and bones associated with the loss of dermis and subcutaneous fat. Both dermal fillers (Table 80-2) and autologous fat transfer have produced significant improvement in hand-specific grading scales and in the patient and investigator assessed Global Aesthetic Improvement Scale.

Table 80-2. Most Commonly Used Fillers for Hand Rejuvenation

	Advantages	Disadvantages
Calcium hydroxyapatite	– Only FDA-approved filler – Biostimulatory and biodegradable – Lasts 12–24 months	– Not reversible – Requires dilution
Hyaluronic acid	– Reversible with hyaluronidase – Does not require dilution	– Tyndall effect if placed too superficially – Lasts <12 months
Poly-L-lactic acid	– Biostimulatory – Lasts 18–24 months	– Dilution is recommended – Higher risk of nodule formation – Multiple treatments are needed
Autologous fat	– No risk of foreign-body reaction	– Requires a donor site – Causes more significant edema – Final results more unpredictable

Certain scales are used to objectively assess the success of cosmetic procedures. In the hand, the most commonly used grading scale for volume loss is the Merz Hand Grading Scale (MHGS), which has been validated for both live and photographic assessment. It is a 5-point scale ranging from 0 (no loss of fatty tissue) to 4 (severe loss of fatty tissue and marked visibility of veins and tendons) (Fig. 80-4).¹³⁻¹⁵ Another scale, the Busso Hand Volume Severity Scale (BHVSS) is a validated 5-point visual scale based on the visibility of three central tendons.¹⁶ This scale was used in the first clinical trial of calcium hydroxyapatite for hand volume restoration in a 2008 German study.¹⁷



Figure 80-4. Merz Hand Grading Scale. 0 = No loss of fatty tissue, 1 = Mild loss of fatty tissue; slight visibility of veins, 2 = Moderate loss of fatty tissue; mild visibility of veins, 3 = Severe loss of fatty tissue; moderate visibility of veins, and 4 = Very severe loss of fatty tissue; marked visibility of veins bands.

FILLER INJECTIONS

During the patient evaluation, the physician should obtain a thorough medical, drug, and allergy history. Each dorsal hand must be examined for areas of volume loss, tendon, and vein visibility, and the physician should formulate a plan as to which specific filler will be used and volume necessary. Specific techniques vary depending on the filler used and physician preference.

Topical anesthetics applied for 30 to 45 minutes may help reduce pain, although this is typically unnecessary. The patient is then asked to wash their hands with soap and water, and chlorhexidine is used as a sterile prep for the entire hand, from wrist to fingertips. It is helpful to identify and mark entry points for the injections. The treatment area should be bounded by the hand–wrist crease, metacarpophalangeal joints, and by the first and fifth metacarpals.¹⁷ The hand can be placed horizontally on a stand, or the injector may choose to hold the hand in order to have greater control. Some physicians place the patient in Trendelenburg position or elevate the hands above the level of the heart in order to reduce venous return, which can potentially minimize edema and ecchymosis.¹¹

Once the treatment is complete, ice can be applied to the hands for at least 10 minutes. Some physicians advise patients to sit on their hands immediately following the procedure in order to decrease edema.³ The hands are often wrapped with a compressive dressing, and the patient instructed to keep the hands elevated as often as possible. Exercise and other physical activities are generally avoided until the edema has decreased. Many fillers have been used for hand rejuvenation. Because of the paucity of data supporting the use of poly-methyl methacrylate (PMMA) and bovine collagen for hand rejuvenation, they are not frequently used for this purpose.

Calcium hydroxyapatite

Calcium hydroxyapatite (CaHA), or Radiesse[®] (Merz Aesthetics, Franksville, WI), is the only dermal filler approved by the United States Food and Drug Administration (FDA) for hand rejuvenation. CaHA microspheres, which are made of substances identical to human bone, are suspended in a polysaccharide carrier made of glycerin and sodium carboxymethylcellulose. This filler is biodegradable (broken down into calcium and phosphate over time) and biostimulatory (stimulates collagen deposition by fibroblasts) (Fig. 80-5).

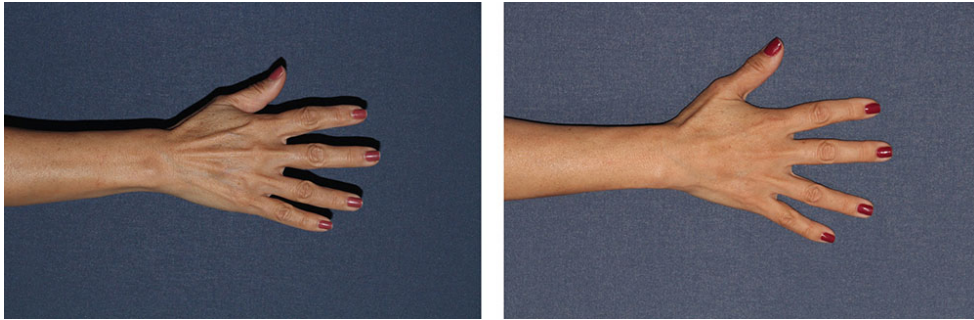


Figure 80-5. A 58-year-old female presented to clinic worried about the aged appearance of the hands, specifically her prominent veins, and wants sclerotherapy of her hands. Upon inspection, it was noted the patient had prominent dorsal hand tendons in addition to veins. Patients are always encouraged to restore dorsal hand volume prior to treating veins alone. Adding volume to the dorsal hands typically minimizes the appearance of the prominent veins while also addressing tendons and improving the quality of skin. Using 1.5 mL of CaHA diluted with 0.5 mL of lidocaine, 1.0 mL of product was injected into each hand. When injecting, it is important to remember that the safest plane of filler injection is the potential space between the dermis and superficial fascia. This plane can be accessed via the scrape skin threatening technique. Before (left) and 14 weeks after (right) 1.5 mL of CaHA mixed with 0.5 mL of lidocaine, 1.0 mL to each hand.

Three prospective, randomized, controlled clinical trials in the United States, Germany, and Canada between 2008 and 2014 and involving a total of 256 patients led to the approval of Radiesse for hand rejuvenation.¹⁷ Using either the MHGS or BHVSS, 66% to 100% of patients achieved at least a one-point decrease in their grading score. Multiple other studies dating to 2007, involving over 100 patients, have demonstrated the efficacy of CaHA for dorsal hand rejuvenation. When used on the dorsal hand, CaHA has been shown to last 12 to 24 months.¹⁸⁻²¹

Previously published literature has reported the use of different dilutions, filler volume, and injection techniques. Overall, dilution of CaHA with lidocaine or saline reduces the viscosity and facilitates an even distribution

of the filler.²¹ Additionally, lidocaine makes the procedure more comfortable for the patient. The various options for injection include the bolus method, linear retrograde, fanning, serial puncture, microdroplets, and cannula.

In the pivotal U.S. trial, no more than two syringes of product were used per hand (1 syringe = 1.5 cc of CaHA mixed with 0.26 cc of 2% lidocaine).¹⁶ Using a 27-G needle, boluses of up to 0.5 cc were introduced via a skin tenting technique, in the area bounded by the first and fifth metacarpals, dorsal wrist crease, and MCP joints.¹¹ The needle is inserted parallel to the bone, and a bolus is placed within the center of the tented skin.¹¹ The bolus is thoroughly massaged into the areas of volume loss until an even surface is achieved. Massage is most easily performed with the hand in a flexed position. Topicals such as emollients, hand soap, chlorhexidine, ultrasound gel, and vitamin K cream may aid in the massage.³

Busso and Applebaum, in the first trial to examine CaHA for hand rejuvenation, used a 1.3 mL vial of CaHA mixed with 0.1 mL of plain 2% lidocaine per hand.²² The syringe of CaHA is attached to a 1-mL syringe of lidocaine using a Rapid Fill™ Luer-Lok-to-Luer-Lok connector (Baxa; Englewood, CO), and the solutions are mixed back and forth until a homogeneous consistency is achieved. A bolus of 0.5 to 1.4 mL was introduced through a needle into the areolar plane between the subcutaneous layer and superficial fascia. Fabi and Goldman in 2012 described their technique of using a 1.5 mL vial of CaHA mixed with 0.3 mL of plain 1% lidocaine and 1.2 mL of bacteriostatic 0.9% sodium chloride in a 1:1 dilution.²¹ After injecting a bolus, similar to Busso and Applebaum, vigorous massage is performed with the assistance of a soapy cleanser.

In their anatomical study, Lefebvre-Villardabo et al. concluded that the safest plane to inject would be the potential space between the dermis and superficial fascia, away from veins and tendons.¹¹ In order to compare the placement of filler using different injections techniques, the authors performed an MRI after injecting CaHA into cadaveric hands. Single bolus of 1 mL using a 21-G needle, single bolus plus massage, blind retrograde threading of 0.8 mL of CaHA using a 27-G cannula, and scrape skin threading technique (SSTT) of 0.7 mL of CaHA using a 21-G cannula were compared. In all techniques except SSTT, MRI showed product in the deep fascia and surrounding tendons. Although this placement of filler in the

subdermal plane seems ideal, little is known about the actual consequences of the presence of filler material in deeper planes.

In SSTT, a soft tip blunt 21- or 23-G cannula is used. First, a needle slightly larger than the cannula creates an entry point in the web space between the MCPs. Next, the cannula is inserted through the entry point with the bevel facing up toward the dermis. The cannula is gently guided toward the wrist; the injector should feel the cannula scraping the underside of the dermis. Then, filler can be slowly and evenly injected as the cannula is withdrawn. The cannula can then be repositioned through the entry point and a fan-shaped configuration used to fill the triangular area of volume loss corresponding to the interosseous spaces. If necessary, additional entry points can be made and the same technique used to fill more proximal areas of volume loss. Gentle massage is used to correct unevenness. This approach may also be used with entry points on the proximal hand near the hand–wrist crease, pointing the cannula toward the MCPs.

In a 2015 study, Gubanova et al. compared a multipoint technique using a needle to a fan-like technique using a cannula.²³ CaHA 0.8 mL with 0.2 mL of 2% lidocaine was used for each injection method. In one hand, a 27-G needle was used to inject 0.025 mL of product into multiple sites. On the other hand, a 25-G, 50-mm blunt cannula was used to distribute filler in a fan-like distribution in the upper subdermal layer. Both techniques resulted in similar response rates, satisfaction scores, and adverse events, all of which were mild (Fig. 80-6).



Figure 80-6. A 66-year-old female had CaHA injections using two techniques. One hand was injected with 1.5 mL of CaHA diluted with 0.5 mL of 1% lidocaine, using a 1.5-in 25-G blunt-tipped cannula and a linear threading technique. The other hand was injected with 1.5 mL of CaHA diluted with 1.5 mL of bacteriostatic normal saline, using a 1.0-in 27-G cannula and a multiple bolus technique.

On occasion, a patient may also desire volume correction of the space between the MCPs and PIPs. Lefebvre-Villardabo et al. recommend injecting only dorsally between the MCP and PIP, and avoiding injecting over the joint or laterally as the arteries and veins run on both sides of the digit. After injection, the filler can be blended with the hand in palmarflexion.¹¹

The expected adverse events of CaHA injection include transient edema, erythema, pain, and ecchymosis lasting up to 2 weeks. In the pivotal trials, pain and edema were the most common adverse events, with 89% of symptoms developing within 14 days.¹⁷ Seven (6.2%) of the patients developed palpable nodules, all of which resolved without intervention by day 268. In certain cases, the onset of swelling can be delayed by 30 days. Busso et al. note that CaHA mixed with lidocaine can produce more prominent edema than using undiluted CaHA.¹⁶ Ice, hand elevation, gentle compression, and light massage can help reduce the edema. Another study evaluated the use of triamcinolone to minimize adverse events associated with CaHA injections.²⁴ Twenty subjects were injected with 1 syringe of CaHA diluted with 0.3 mL of 1% lidocaine and 1.2 mL of bacteriostatic normal saline. Following treatment, each hand was randomized to receive

injections of either 5 mL of 2 mg/mL triamcinolone acetate or 5 mL of bacteriostatic normal saline. A blinded investigator noted a decrease in edema at days 7 and 14 postinjection in the triamcinolone-treated hands ($p < 0.10$). This was corroborated by a statistically significant increase in swelling from days 6 to 19 in the placebo hand, documented in the subjects' daily diary. No statistically significant difference in treatment efficacy was noted between those treated with triamcinolone or placebo.

Hyaluronic acid

HA, a naturally occurring glycosaminoglycan, can also be used for hand rejuvenation. Man et al. and Brandt et al. demonstrated the efficacy of Restylane® (Medicis Aesthetics Inc., Scottsdale, AZ), a small gel-particle (SGP) non-animal-derived stabilized (NASHA) made of 20 mg of HA per mL, for volume augmentation in a total of 48 patients (10 and 38, respectively).^{25,26} In their study, Man et al. compared 2 vials of SGP-NASHA to 2 vials of human collagen. With the patient in Trendelenburg position, filler was injected subcutaneously, inserting the needle at an oblique angle adjacent to the dorsal hand veins. Gentle massage was then performed with the hand in a flexed position. HA was found to be more painful (likely due to the presence of lidocaine in human collagen), but produced greater patient satisfaction; it was also more efficacious at improving the physician-assessed visibility of dorsal hand veins. In order to decrease pain during massage, NASHA can be premixed with lidocaine.²¹

SGP-NASHA (20 mg/mL) was used on 16 patients by Brandt et al.²⁶ This study found substantial improvement in the prominence of vessels, tendons, and bones, in skin turgor, and in patient and investigator global aesthetic improvement and satisfaction scales. Using a single entry point, the material was threaded along the dorsum of the hand. The authors did not indicate whether a needle or cannula was used. The mean volume used for both hands was 7.38 mL, with a maximum of 4 mL per hand. Five patients underwent a touch-up treatment at 2 weeks, using a mean volume of 1.96 mL for both hands.

A European study treated 99 patients with Juvéderm® (Allergan, Inc., Irvine, CA, USA).²⁷ Juvéderm Ultra 3, with volume of 0.8 to 1.6 mL, was injected into the mid to deep dermis at the first visit. Injections were

performed via cannula in 54.3% of patients, and the rest through needle. Juvéderm Hydrate, with a volume of 0.5 to 1.0 mL was injected into the superficial dermis at day 15. Injections were performed via needle in 79.3%, and the rest through cannula. The study demonstrated a significant improvement in patient and investigator assessments. Interestingly, the proportion of injections rated as “very easy” was significantly higher with needle for Juvéderm Ultra 3, than with cannula for Juvéderm Hydrate. Edema, hematoma, redness, and pain were experienced by 13.2% of patients. Of these 32 adverse events, 26 were reported with cannula and 6 with needle. Additionally, subject discomfort was found to be significantly greater with cannula injections (Fig. 80-7).

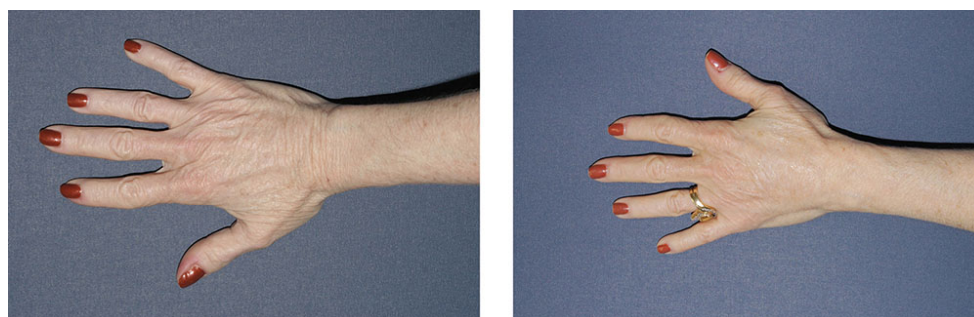


Figure 80-7. Fat transfer to the hands was elected to restore volume to the patient’s hands as she was already planning to undergo liposculpture. Otherwise, CaHA would have been the filler of choice to avoid undergoing a costly harvesting procedure that adds a different set of side effects from simply using a synthetic filler. Before (left) and 30 days after (right) 8 mL of autologous fat to the dorsal hand.

Another study compared 27-G hypodermic needles to blunt-tipped microcannulas (using either a 25-G 50-mm flexible microcannula or 18-G 70-mm semi-rigid microcannula) on the dorsal hands.²⁸ A total of 95 patients were injected with 20 to 28 mg/mL of HA. In both methods, the filler was placed in a linear retrograde fanning technique. The authors found that while there was no difference in the GAIS score between the two techniques, pain and bruising were greater with the use of a hypodermic needle.

In a placebo-controlled study, Gubanov et al. utilized a multipuncture, microinjection technique to assess NASHA versus saline in 30 patients.²³ A 30-G needle was introduced 3 to 4 mm into the dermal layer, delivering 0.02 mL of product. Approximately 50 injections were placed at even intervals along the dorsal hand until the desired outcome was achieved. Patients received 1.0 mL of HA or 1.0 mL of saline monthly, for a total of three

treatments. HA showed a significant improvement in patient and investigator questionnaires and measurements of skin hydration and elasticity.

Restylane[®] Vital[®] or Vital Light[®] (Q-med, Uppsala, Sweden) have been used for hand rejuvenation in parts of Europe and Asia. Unlike other Restylane products, Restylane Vital contains 12 mg/mL of HA. Streker et al. employed the Restylane[®] Injector[®] (Q-Med AB, Uppsala, Sweden) to deliver a controlled volume of 10 μ L per injection into the mid dermis, using a 30-G needle.²⁹ Injections were spaced 0.5 to 1.0 cm apart. A mean of 2.8 mL of NASHA was injected per hand. All patients demonstrated aesthetic improvement and increased satisfaction through the 36-week follow-up. Lacarrubba et al. also applied an autoinjector to dispense aliquots of approximately 17 μ L of either 16 or 20 mg/mL HA salts (Viscoderm; Bigpharma, Seixal, Portugal) per injection.³⁰ Each hand received 30 microdroplets at a maximum volume of 1.0 mL. Patients received treatment every week for 4 weeks. Ultrasound was performed prior to each treatment and 1 week following the fourth injection. Fifteen of 19 subjects demonstrated a statistically significant increase in subepidermal low-echogenic band echogenicity, which the authors believed to represent an increased density of collagen fibers produced by activated fibroblasts.

Side effects of HA injection in these studies included pain, edema, and ecchymosis. The results produced by HA are expected to last 6 to 12 months.²¹ HA has the advantage of being reversible with hyaluronidase. However, it has a shorter duration, requires more syringes per hand to achieve a significant improvement, and has the potential for causing the Tyndall effect if placed too superficially; no studies have reported Tyndall effect with the use of HA on the hands.

Poly-L-lactic acid

Another well-studied product is poly-L-lactic acid (PLLA), or Sculptra[®] Aesthetic (Galderma Laboratories, Fort Worth, TX), which is a biodegradable and biostimulatory filler. The first use of PLLA for hand rejuvenation was described in 27 patients by Radaelli in 2006.³¹ A 150 mg vial of PLLA was diluted with 0.5 mL of 3% mepivacaine, and sterile water to achieve a volume of 5 to 8 mL, typically using higher concentrations in the first session. The dilution is made 12 hours before injection and stored at

room temperature. With each treatment, a maximum of 2 mL of the 5- to 8-mL solution was used per hand. Injections were made with a 2.5-mL syringe and 25- to 27-G needle, entering the skin parallel to the metacarpal bones, although at times in various directions. With each injection, volumes of 0.05 to 0.1 mL of product were placed into the deep subcutaneous tissue. During the procedure, patients were kept in a Trendelenburg position in order to decrease venous pressure. Immediately following treatment, each hand was massaged for 15 minutes, and the patient was encouraged to continue massage at home at least twice a day for 3 days. Patients receiving PLLA had a measurable decrease in the visibility of veins and tendons, in addition to an improvement in patient and investigator satisfaction scores. In the study, patients required between 3 and 6 sessions about 1 month apart. One patient developed a nontender, nonvisible palpable deep nodule noticed at the last follow-up visit. PLLA with dilutions of 5, 6, and 7 mL were used at the first, second, and last session. Raedelli believed the nodule was likely due to errors in injection and massage done during the first two sessions.

In a 2008 study, Sadick et al. treated 26 patients with PLLA.³² A 367.5 mg vial was reconstituted with an 8- to 10-mL mixture of sterile water and 1% lidocaine. Using a 1- or 3-mL syringe attached to a 25-G 1.5-in needle, the product was introduced into the deep subcutaneous space using a tenting maneuver. One half vial, or 5 mL, was used per hand. Apart from massage done immediately postinjection, patients were asked to massage for 5 minutes at a time, 5 times per day, for a total of 5 days (“5–5–5” rule). Patients received an average of 2.38 treatments 1 to 2 months apart. No papules or nodules were reported.

Eight patients had their hands treated with PLLA by Palm et al.³³ A 367.5 mg vial of PLLA was reconstituted with 1 mL of 1% lidocaine (with or without epinephrine) and 5 mL of bacteriostatic water the day before treatment. The day of treatment, a Vortex Genie (Scientific Industries, Inc., Bohemia, NY) was used to agitate the product. Then, 1.5 mL of agitated product and 1.5 mL of bacteriostatic water were drawn into a 3-mL syringe. The final reconstituted product should equal 12 mL, with 6 mL used per hand. Using a 25-G, 1.5-in syringe, product was injected into the subcutaneous tissue plane in a retrograde fanning technique. Subjects were instructed to perform vigorous massage and keep to the “5–5–5” rule. Patients received an average of 2.5 treatments. One of the eight (12.5%)

patients who received PLLA to the hands developed a nodule; this patient had been treated once with a 9 mL dilution.

When treating off the face with this product, one approach is to reconstitute 1 vial of PLLA overnight with 1 mL of 1% lidocaine and 7 mL of bacteriostatic water. Though the manufacturer recommends sterile water for reconstitution, the vast majority of physicians utilize preserved (bacteriostatic) water, as the preservative decreases patient discomfort during cosmetic injections.³⁴ The reconstituted product is agitated with the Vortex Genie mixing device immediately prior to injection, and then 1.5 mL is withdrawn into a 3-mL syringe. Next, another 1.5 mL of bacteriostatic water is withdrawn into the syringe resulting in a combined total volume of 3 mL. This step is repeated until a final total of 16 mL is mixed and withdrawn into the syringes. A 16 mL dilution cannot be done at the outset, as the vial can only hold up to 10 mL of diluent. Half of the PLLA vial (or 8 mL) is used per hand. The length of correction with PLLA has been reported to last 18 to 24 months, but requires multiple treatments spaced 4 to 6 weeks apart.¹⁸

Besides developing edema, ecchymoses, and hematomas, PLLA can lead to the formation of nodules.³⁵ Because of this, and the availability of other filler agents, PLLA should be used with caution for hand augmentation. A 10-year retrospective review by Park et al. published in 2012 identified 15 patients who developed foreign-body granulomas.³⁶ Four patients had been treated with PMMA, three with CaHA, three with HA, two with PLLA, and two with “other” material. Subjects had been symptomatic from 1 month to 9 years, with 12 of the 15 having symptoms for more than 1 year. Four patients (two with PMMA, two with other filler) had sensory dysfunction, and four (two with other, one with PMMA, one with CaHA) developed hand stiffness.

In their article, Park et al. recommended an algorithm for dealing with nodule formation. First, the authors started an antibiotic trial consisting of a second-generation cephalosporin combined with a third-generation macrolide. If the nodule persisted despite antibiotics, hyaluronidase was used for HA fillers, excision for CaHA, and intralesional triamcinolone for other types of filler. Excision was reserved as an intervention of last resort.

For those who use PLLA, there are techniques that can decrease nodule formation: using dilutions greater than 5 mL (16 mL is advised), using smaller volumes, not overcorrecting, spacing treatments at least 4 weeks apart, reconstituting the product the night prior, and performing massage after

treatment.²¹ Although the Sculptra product insert recommends reconstitution with 5 mL of sterile water at least 2 hours before treatment, dilutions less than 5 mL are associated with an increased risk of nodule formation.³²

Autologous fat transfer

Autologous fat transfer is yet another method that can augment the volume of the dorsal hand. The general procedure involves harvesting fat from a donor site and introducing it into a host tissue. Aside from being abundantly available, adipose tissue has the benefit of being biocompatible.¹ Autologous fat transfer has been shown to last 4 months to 3 years on the dorsal hand.^{21,37} For a detailed discussion of fat transfer, see [Chapter 61](#).

This procedure first showed promise for dorsal hand augmentation in the 1980s.²¹ Thereafter, both Fournier and Coleman published their methods for autologous fat transfer to the dorsal hand. Fournier applied a single large bolus to the dorsal hand, while Coleman produced multiple small tunnels in order to increase the surface area of contact between the transplanted adipose and recipient tissues.^{1,38,39} Studies have shown this increase in surface area contact is beneficial, as 60% of adipocytes die if they are more than 1 mm away from blood supply.⁴⁰ In addition, Carpeneda showed that the diameter of the fat injected must be 3 mm or less in order for revascularization to occur.^{1,40}

Many methods exist for harvesting, preparing, and delivering adipose tissue.^{1,37,38} In a review of autologous fat transfer for the hand, Hoang et al. recommend choosing adipose tissue from the abdomen, flank, thigh, or medial knees, as these areas produce a more bloodless fat.³⁶ First, the donor site is anesthetized with a tumescent solution of lidocaine and epinephrine 15 minutes prior to collection. A 2- to 3-mm cannula is attached to a 10-mL harvesting syringe, and 15 to 40 mL is harvested per hand.¹

The harvested fat is then set upright for 15 minutes to allow the supernatant fat to separate, and the fluid is then poured off.^{1,37} A 10-mL syringe is filled with supernatant fat and may be centrifuged at 3,000 to 3,600 revolutions per minute for 3 minutes.^{1,37} While Butterwick suggested that, on the dorsal hand, centrifuged fat has increased longevity and better clinical results compared to noncentrifuged fat, the question of whether centrifugation

results in a net benefit is controversial.⁴¹ Fat is then placed into 1-mL syringes.

Before proceeding with injections, the hands are prepped in a sterile fashion. One to 2 mL of tumescent anesthesia solution may be introduced through the dorsal wrist crease.³⁷ The bolus of anesthesia is then massaged onto the remainder of the dorsal hand. Agostini et al. perform median and ulnar nerve blocks instead.⁴²

The next injection methods vary by author. Butterwick uses an 11 blade to create an entry point on the dorsal wrist crease.³⁷ Then, a number 10 Amar or Byron needle is introduced on the dorsal wrist crease toward the web space, and aliquots of approximately 0.3 mL are placed with each retrograde linear thread. A weaving crisscross pattern is used to place these aliquots throughout the dorsal hand. The hand should appear slightly overfilled, but the total injection volume to be kept to less than 10 to 12 mL per hand in order to limit the amount of postoperative edema.

Other authors use higher volumes. Bank et al. place 10 to 15 mL onto the dorsal hand, 1 to 2 mL onto the second, third, and fourth web spaces, and 2 to 3 mL onto the first web space and over the area of the anatomic snuffbox.⁴³ Using a 16-G needle, Agostini makes six total entry points at the dorsal wrist crease, each of the web spaces, and one at the proximal radial aspect of the first MCP joint. All injections are performed using cannulas. From the entry on the dorsal wrist crease, 5 to 10 mL of fat is placed onto the dorsal hand, using 6 total passes in a fanning distribution. From the entry on the web spaces and first MCP, the cannula is pointed proximally and an additional 5 to 10 mL is placed on the dorsal hand, in a retrograde linear fashion. Agostini also treats the digits. By entering the perforations in the web spaces or first MCP, linear anterograde injection is used to place 0.5 mL of fat onto the radial and ulnar aspect of each digit. In their study, 21 of 22 patients were either “satisfied” or “very satisfied” with the treatment, and independent plastic surgeons rated 18 of 22 patients “very improved” and the remainder “significantly improved.”

Some authors apply Steri-Strips (3M Nexcare, St. Paul, MN) or Octylseal (Medline Industries, Mundelein, IL) to the incisions sites.⁴³ Butterwick recommends starting a 10-day course of oral antibiotics the evening prior to the procedure.³⁷ After injection, a soft dressing can be applied for 5 days.¹

To minimize edema, the hand is elevated for the first 24 hours and the patient should avoid strenuous activity for 1 week.²¹

Patients should expect to experience edema and bruising lasting 1 to 2 weeks. Infection (including mycobacterial), cyst formation, and transient dysesthesia have also been reported.^{37,44} In the Agostini study, 3 of the 22 patients developed sensory dysfunction of the distal phalanges, which resolved within 1 month. Furthermore, rejuvenation of the digits led to 16 of the 22 patients unable to wear their rings postoperatively. Only 5 of the 16 patients considered the increase in ring size an inconvenience. Agostini argues that finger rejuvenation contributed to a high satisfaction rate with the global appearance of the dorsal hand. On the other hand, Coleman contends fat injection to the fingers should be avoided to maintain the same volume and ring size of the digits. Many dermatologic surgeons do not volumize the fingers.

TREATMENT OF VISIBLE VEINS

Dorsal hand veins become more visible in the aging hand. Their visibility can often be minimized with revolumization of the dorsal hand. For patients who decline dermal fillers, or for those who still have prominent veins despite revolumization, treatment of dorsal hand veins alone may be an option. While neither sclerotherapy, endovenous vein ablation, nor phlebectomy is well studied, sclerotherapy is the most commonly used on the dorsal hands.

Sclerotherapy

In sclerotherapy, a liquid or foam is injected into a vein in order to produce endothelial cell damage and resultant vessel sclerosis. Various agents can be used to perform sclerotherapy. On the hand, the detergents sodium tetradecyl sulfate (STS) (Sotradecol Elkins-Sin, Inc., Cherry Hill, NJ) and polidocanol (POL) (Asclera; Kreussler, Chemische-Fabrik, Wiesbaden, Germany) are most commonly used. Both are FDA approved for small varicosities of the lower extremity. Thus, their use on dorsal hand veins is off-label.

Good candidates for sclerotherapy are patients with bulging dorsal hand veins who do not have known contraindications to sclerotherapy. For the

hands specifically, sclerotherapy should be avoided in patients with a history of hand surgery, need for frequent intravenous access, hand arthritis, chronic edema or pain of the hands, functional abnormalities of the hands, carpal tunnel syndrome, or dialysis shunts.¹⁰

Prior to starting the treatment session, the patient is seated with the arms positioned perpendicular to the upper body. The entire hand and wrist are prepped with chlorhexidine. A tourniquet, or pressure from an assistant's hand, is applied to the mid-forearm in order to increase the prominence of the veins, making them easier to inject.

Concentrations of 0.5% to 3% liquid STS or 1.5% to 3% liquid POL are most commonly used. In general, lower concentrations should be used for smaller veins, and higher concentrations for larger veins. Duffy et al. treated 100 patients with dorsal hand veins ranging from 1 to 6 mm in diameter (mean of 3 mm) with liquid 0.5% STS, 1.5% POL, or 3% POL.⁴⁵ They observed higher success rates in patients treated with 3% POL (95% vs. 20% success rate). The authors concluded that 3% POL is more effective in vessels larger than 3 mm, or vessels of any diameter in younger patients. It is important to note that 14.5% of the patients treated with 3% POL developed telangiectatic matting in the treatment area, a side effect which was not observed with 0.5% STS or 1.5% POL. Bowes et al. reported complete resolution of 3 to 6 mm dorsal hand veins in 11 of 14 (79%) hands treated with 1 to 4 mL of liquid 1.5% to 3% STS.⁴⁶

With foam sclerotherapy, the sclerosing solution is mixed with either room air or carbon dioxide (CO₂) gas. Foaming allows for longer contact between the sclerosant and the endothelium, increasing the efficacy of the procedure and allowing the physician to use lower concentrations and smaller volumes of sclerosant.⁴⁷ Rao et al. attach a 3-mL syringe filled with 1 mL of the sclerosant to a 5-mL syringe containing 4 mL of room air. A female-to-female connector is used to attach the two syringes. The liquid and room air are mixed together approximately 10 times until a homogeneous consistency is achieved. Either 0.5% STS or 1% POL, with a total of 3 to 5 mL of foamed sclerosant per hand, is frequently used.²¹ In a retrospective review of 38 hands, Tremaine et al. used 2.5 to 10 mL of foamed 0.25% to 1% STS per hand, with 0.5% and 0.25% predominating.¹⁰

For practical purposes a single hand is treated per day, generally using a 30-G, 0.5-in needle connected to a 3-mL syringe of sclerosant. The vein

should be entered at its most distal aspect and canalized in a proximal direction. With the bevel of the needle facing up, the vein is directly punctured, entering at an angle of 30 to 45 degrees to the skin. The sclerosant is injected slowly. Once all the desired vessels are treated, the tourniquet is released, the hand is elevated, and gentle massage is performed to the treated area from a distal to proximal direction. Cotton swabs are then applied to each treatment site, and the hand and distal forearm are wrapped in an elastic bandage. The patient is asked to keep the bandage on for 24 hours, and can return for treatment of the second hand the following day so that the other hand is free to assist with daily function. Signs of excessive compression from the bandage include paresthesias, decreased motion, or changes in temperature or color of the fingers. Some authors recommend keeping continued compression for 2 weeks.⁴⁸

Common side effects due to sclerotherapy include pain during the injection, ecchymosis, edema, and soreness. Tremaine et al. noted pain lasted an average of 7.4 days, edema and erythema 3 to 4 days, and ecchymosis 3.7 days.¹⁰ Less frequently, patients may develop hyperpigmentation, neovascularization, localized hypertrichosis (never reported in the hands), urticaria, and allergic reactions. In their study, Tremaine reported that 61.9% of 38 treated hands developed posttreatment coagulum. A 22-G needle can be used to pierce the center of the coagulum, and its contents can be gently expressed; all coagula in the study resolved within 2 months. Patients should be seen for follow-up at 2 weeks to assess for this complication. Neovascularization, or telangiectatic matting, more often occurs in patients with high levels of estrogen, as seen during pregnancy and the use of oral contraceptives or estrogen supplementation.^{49,50} High volume of sclerosant, high injection pressure, large treatment areas, extensive blanching upon injection, and lack of posttreatment compression are also associated with the development of neovascularization.^{50,51}

Rare adverse events include local skin necrosis, arterial injection resulting in distal skin necrosis, thrombophlebitis, DVT, wheezing in asthmatics, and angina in cardiac patients.⁵² Duffy et al. reported one patient who, after treatment of vessels located on the thenar web, developed blanching of the thumb, index, and middle finger for 10 minutes.⁴⁵ The patient then experienced 2 weeks of numbness and paresthesia. These symptoms were thought to be secondary to neuropraxia caused by extravasation of the

sclerosing agent. Although never reported in treatment of the dorsal hand, the microbubbles introduced into the circulation by foam sclerotherapy can cause visual changes, headache, chest tightness, coughing, migraine with or without aura, and transient ischemic attacks (Fig. 80-8).

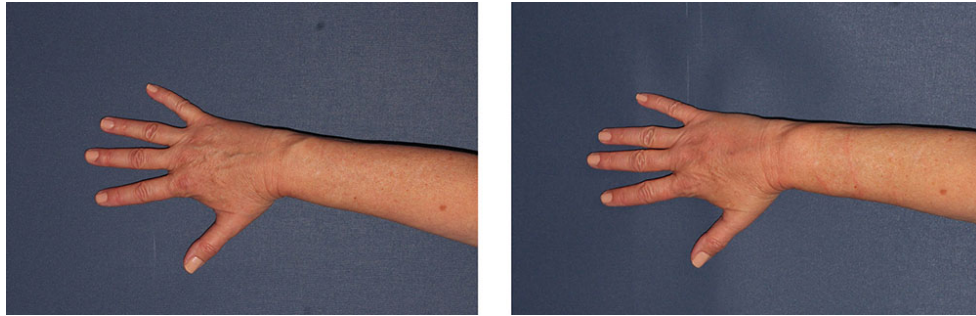


Figure 80-8. A patient was extremely bothered by her prominent hand veins. She had no history of diabetes or kidney disease, and denied need for frequent IV access. The patient did not want to have any fillers injected, and was not bothered by prominent tendons or the quality of skin. She subsequently underwent sclerotherapy. Before (left) and 24 hours post (right) foam sclerotherapy to the dorsal hand.

Endovenous laser ablation and phlebectomy

Endovenous laser ablation and phlebectomy are other methods of treating prominent dorsal hand veins. While widely used for leg veins, these procedures have not been well studied in the dorsal hand.

In endovenous laser ablation, a laser fiber is introduced percutaneously into a vein through a catheter and guide wire. The energy emitted by the laser causes damage to the vessel wall, causing obliteration of the treatment area. In a 2007 article, Shamma et al. detailed their methods for endovenous laser ablation in 54 hands.⁵³ While wavelengths of 810 to 1320 nm have been used in the legs, Shamma et al. used a Dornier MedTech 940-nm diode laser (Medilas Compact; Dornier MedTech Laser GmbH, Germering, Germany). After tumescent anesthesia, a 600-micron laser fiber was introduced through a 4-F laser sheath, tracked over a 0.018-in guidewire. An average of four veins was treated per hand, and a compressive dressing was applied postoperatively. All patients were satisfied with their treatment. Hand swelling was a common side effect that lasted up to 2 weeks. One patient developed a 3-mm burn at a laser exit site.

Phlebectomy involves the removal of a desired length of the vein through 2 to 3 mm incisions in the skin. Only one case report has been published on

this procedure for dorsal hand veins in the literature.⁵⁴ Because endovenous laser ablation and phlebectomy require specialized instrument, materials, and staff in order to be performed safely and effectively, sclerotherapy remains a dermatologic surgeon’s first-line option for the treatment of dorsal hand veins.

LIGHT-BASED THERAPIES

Various light, laser, and energy devices have been used for hand rejuvenation. These include IPL, photodynamic therapy (PDT), Q-switched (QS) lasers, 1,320-nm neodymium-doped yttrium aluminum garnet (Nd:YAG) laser, fractioned 1,550-nm erbium-doped laser, fractioned 1,927-nm thulium laser, 2940-nm erbium-doped YAG (Er:YAG) laser, and fractioned 10,600-nm CO₂ laser (Table 80-3). Since the dorsal hand skin is thinner, has a decreased vascularity, and fewer pilosebaceous units than the face, the fluence, density, and number of passes should generally be reduced to minimize recovery time.²¹

Table 80-3. Light-Based Approaches

Approach	Indications	Disadvantages
Q-switched laser	Pigmented lesions	Dyschromia, erythema, scarring, textural change, bleeding, bullae formation
IPL	Pigmented and vascular lesions can be treated simultaneously	Requires multiple treatment sessions
Photodynamic therapy	Actinic keratoses	Pruritus, erosions, erythema, edema, and pain
Nonablative laser resurfacing	Neocollagenesis	Subtle and mild improvement, cost, requires multiple treatments
Nonablative fractionated laser	Photoaging and neocollagenesis	Erythema, edema, and pruritus, less noticeable improvement than fractionated laser
Ablative resurfacing	Photoaging and neocollagenesis	Infection, dyschromia, scarring

A frequent patient complaint about their hands is the development of solar lentigines and macular seborrheic keratoses. These rarely resolve permanently with topical superficial peeling agents. Selective photothermolysis of the pigment within melanosomes, such as that employed by QS lasers, is highly effective.⁵⁵ Melanin has a broad spectrum of wavelength absorption across the optical spectrum. Preferred lasers have wavelengths from approximately 500 to 755 nm. Since the thermal relaxation time of melanosomes is only 0.25 μ s, short pulse durations are optimal.⁵¹ For this reason, the QS ruby laser (694 nm), QS or picosecond alexandrite laser

(755 nm), and the frequency-doubled QS or picosecond Nd:YAG laser (532 nm) are most often employed (Table 80-4).^{56,57} These devices deliver pulse durations in the nanosecond and picosecond range, respectively. Usually a one-time treatment is required, and the fluence should result in epidermal whitening without vesiculation or pin-point bleeding. A single pass is typically performed, but pulses may be stacked over macular seborrheic keratoses.

Table 80-4. Q-Switched Lasers in the Treatment of Epidermal Pigmented Lesions (in order of decreasing effectiveness)

Frequency QS ruby
Doubled 532 nm Nd:YAG
QS alexandrite
1,064-nm Q-switched Nd:YAG

In a study comparing three lasers and liquid nitrogen (Medlite II frequency-doubled QS Nd:YAG laser, Continuum Biomedical, Livermore, CA; HGM K1 krypton laser, HGM Medical Laser Systems Inc., Salt Lake City UT; DioLite 532-nm diode-pumped vanadare laser, Iridex Corp, Mountain View, CA), a single treatment with the frequency-doubled QS Nd:YAG laser was the most effective agent at destroying melanin and preserving the surrounding tissue.⁵⁸

For QS and picosecond lasers, patients should be counseled that they may see urticarial-like papules for 24 hours followed by 7 to 10 days of purpura or coffee-ground appearing macules, followed by temporary hypopigmented macules, which can be seen after the lesion sloughs superficially (Table 80-5). Purpura is more frequently encountered with the QS Nd:YAG (532 nm) or pulsed-dye lasers because the competing chromophore, deoxyhemoglobin, causes immediate rupture of small vessels.⁵³ The use of the QS ruby laser is not recommended in darker skin types. These can be more safely treated with the 1,064-nm QS or picosecond Nd:YAG laser.³⁷

Table 80-5. Frequent Adverse Events of Laser Therapy

Erythema
Hypopigmentation and hyperpigmentation
Scarring
Textural change
Crusting
Bleeding
Bullae formation

IPL therapy has been used as a nonablative photorejuvenating device for the hand. IPL systems are high-intensity pulsed sources emitting light between 515 and 1,200 nm. This broad spectrum facilitates the selective targets of vessels with hemoglobin (580 nm), or deoxyhemoglobin and melanin (400–755 nm). Its largest advantage is that it allows simultaneous correction of vascular and pigmented lesions with little to no downtime.⁵⁹ Additionally, dermal heating from IPL therapy, which spares the epidermis, has been shown histologically to induce collagen production in the papillary and reticular dermis.⁶⁰ Filters can be added to select for wavelengths only above a certain range. Fitzpatrick skin types IV to VI require cut-off filters at higher wavelengths, triple pulsing and longer pulse delays between pulses in order to prevent damage or epidermal compromise (Table 80-6). Optimal correction of erythema and vascular lesions, where oxygenated hemoglobin predominates, can be achieved using 515- to 590-nm cut-off filters (based on patient skin type and extent of erythema). Purpuric patches (rich in deoxygenated hemoglobin) are better targeted with filters of 590 nm or higher.

Table 80-6. Fitzpatrick Skin Type and IPL Filter

I–III	560 nm
IV	590 nm
V	695 nm
VI	755 nm

Settings using the Lumenis 1 or the Lumenis M22 IPL (Lumenis Ltd., Yokneam, Israel) are optimized with a 560-nm cut-off filter for skin types I to III and a 590-nm filter for skin type IV, is used. Patients with predominantly mottled hyperpigmentation and solar lentigines benefit from a double-pulse technique with a 3-ms pulse duration. If there is a combination of pigment and vascular structures, a 3.5-ms pulse duration for both pulses is used, and a 4-ms pulse duration is used if only fine telangiectasias and erythema predominante. A 10- to 30-ms delay is set between pulses in skin types I to III and a 30- to 40-ms delay in skin type IV. The fluence is set between 15 and 18 J/cm². Treatments are performed monthly for two or three sessions.

In a study by Goldman, 23 patients with dermatoheliosis and solar lentigines on the dorsal hands were treated with four IPL sessions at 3- to 4-week intervals.⁶¹ In 100% of cases, investigators noted good to excellent results in the improvement of lentigines and skin quality. Subjective patient self-assessments showed similar results. Twenty of 23 (87%) of subjects noted good to excellent improvement. No significant side effects were observed (Fig. 80-9).

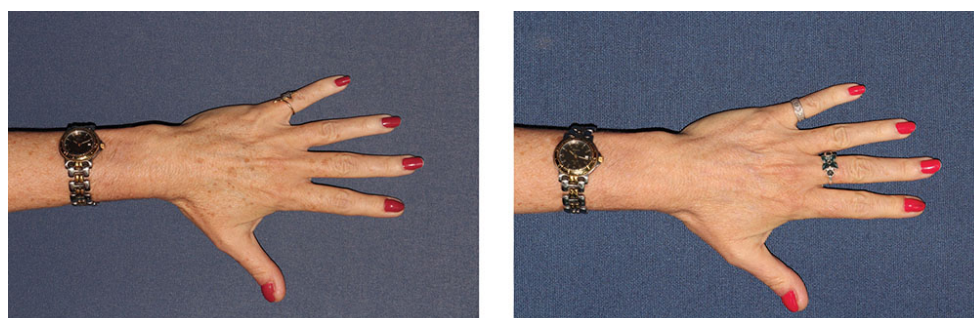


Figure 80-9. A 57-year-old patient presented with fine wrinkling, solar lentigines, and macular seborrheic keratoses of the dorsal hands and digits. She underwent one session of intense pulsed light and Q-switched alexandrite to the hands, with improvement in texture and pigmentation. Before (left) and 4 weeks after (right) one session of intense pulsed light and Q-switched alexandrite to the hands.

PDT is an effective photoaging treatment, especially in the presence of precancerous conditions. PDT uses a photosensitizer, such as 20% aminolevulinic acid (ALA) solution or 16% methyl aminolevulinate (MAL) cream, which is converted in vivo into protoporphyrin IX. PDT is indicated for the treatment of nonhyperkeratotic actinic keratoses, with the advantageous side effect of improving the appearance of fine lines and rhytides, mottled hyperpigmentation, and texture.⁵³ To increase efficacy from

a single PDT treatment, patients may apply other topicals (imiquimod or 5-fluorouracil) for 7 to 10 days prior to PDT treatment to the area to be treated. ALA or MAL may be applied after the dorsal hand skin has been exfoliated with a vibrating microdermabrasion system (if available) and degreased with an acetone wash. On the hands, photosensitizer may be left in place for 3 hours occluded, and ideally under a warming blanket or in a warm dimly-lit room. After the photosensitizer has been washed off with soap and water, and a baby wipe has been used to remove any additional residue, any light source within the visible light spectrum can be used to activate the photosensitizer. Friedman et al. found a sequential combination of laser and light sources to be superior to using a single light source.⁶²

The sequence is as follows: initial activation with a PDL (Cynergy, Cynosure, Westford, MA) 595 nm with a 7 mm spot size, 40-ms pulse width, and 10 to 12 J/cm² targeting individual actinic keratoses so that the endpoint is subpurpuric. This is followed by the IPL using the treatment parameters outlined above. Finally, the treatment area is concomitantly illuminated with a blue light source (Blu-U, DUSA Pharmaceuticals, Inc., Wilmington, MA) positioned 25 to 50 mm from the skin for an illumination period of 16 minutes 40 seconds, light dose 10 J/cm² and a red light source (Aktilite CL 128, PhotoCure ASA, Oslo, Norway) positioned 50 to 80 mm from the skin for a total of 8 minutes, 49 seconds at a standardized fluence of 37 J/cm². Prior to discharge home, a mineral-based sunscreen is applied and the patient is told to stay indoors with strict sunlight avoidance for the remainder of the treatment day and the following day. Using this combination, generally one PDT treatment is sufficient. Orringer et al. examined the histologic effects of PDT on the hand and found an increase in expression of procollagen types I and III, epidermal thickening, and an increase in Ki-67, a keratinocyte differentiation marker, after PDT using a 595-nm PDL for activation of the photosensitizer.⁶³

Nonablative laser resurfacing also improves the appearance of photodamaged skin of the hand. These lasers emit longer wavelengths, in the mid-infrared range, that penetrate into the deep dermis, stimulating fibroblasts while avoiding injury to the epidermis.

The 1,320-nm Nd:YAG laser been employed as a treatment modality in hand rejuvenation. Sadick and Schecter performed a study involving seven patients using the 1,320-nm Nd:YAG laser (CoolToughII, New Star Lasers,

Roseville, CA, USA).⁶⁴ These patients received six treatments separated by 4 weeks and were followed for 3 months after the last treatment. Patient assessment scores were higher than objective measures, with six of seven patients reporting a mean improvement score of 2 (range 1–6), corresponding to 1% to 19% improvement from baseline. Results are mild to moderate at best, and patients should be warned of the slow progress and subtle improvement that can be expected.

Nonablative fractional lasers treat a fraction of the skin as compared with traditional nonablative lasers, leaving up to a maximum of 95% of the skin uninvolved. Microthermal treatment zones (MTZs) are delivered to the dermis, causing coagulation necrosis followed by collagen remodeling. The selected wavelength should correspond to the cosmetic target; the 1,550-nm wavelength is best for stimulating collagen production and improving skin texture, while the 1,927-nm wavelength and 1,927-nm thulium lasers are best for pigmentation (Table 80-7).⁶⁵ Jih et al. employed fractional resurfacing technology for hand rejuvenation using the 1,550-nm diode-pumped erbium fiber laser (Fraxel SR, Reliant Technologies) on a series of 10 patients.⁶⁶ Patients received a total of 5 treatments 2 to 3 weeks apart using a setting of 8 to 9 mJ/MTZ with 10 passes at 250 MTZ/cm² to achieve a final treatment density of 2,500 MTZ/cm². The study reported a subjective patient improvement of 51% to 75% in skin pigmentation and 25% to 50% improvement in skin roughness and wrinkling. Biopsies of the skin showed an increase in density of dermal collagen. It may be best to use one wavelength per session to allow a more focused treatment and include a greater number of passes.

Table 80-7. Common Settings for Nonablative Fractional Laser

Laser Wavelength	Number of Passes	Fluence	Coverage/Fitzpatrick Skin Type
1,550 nm	8	20–35 mJ	14–28% (I–III), 14–20% (IV–VI)
1,927 nm	8	10–20 mJ	40–50% (I–IV)

Fractionated 1,927-nm thulium laser and the second-generation fractionated 1,550-nm erbium-doped laser (Fraxel Re:Store Dual system, Solta Medical, Inc.)

Ablative laser skin resurfacing using the CO₂ or Er:YAG laser is the standard for facial rejuvenation. When employing this modality for hand rejuvenation, great caution should be taken because of the reduced number of pilosebaceous structures and vasculature. This leads to a lengthier recovery

period, a higher risk of infection, and a greater risk for scarring and dyschromia. Optimal treatment parameters using the Er:YAG laser that have been reported in the literature include the use of two passes at 15 J/cm² and 30% intensity, followed by cleaning and a third pass at the same settings.⁵³ A single-pass resurfacing technique has also been described using decreased fluence (150–200 mJ/pulse) with a computer-generated pattern of 6, leaving the epidermal debris in place to serve as a biologic dressing.¹

Fractional thermolysis can also be employed by ablative fractional lasers. This creates columns of vaporized tissue and coagulation necrosis. Because only a small portion of the skin is affected, neighboring untreated tissue aids in the healing process promoting a favorable side-effect profile and minimal posttreatment recovery. Stebbins et al. treated the hand with a single-pass of the Dermal Optical Thermolysis ablative fractional CO₂ laser (DEKA, Calenzano, Italy) and noted transient erythema and edema, with no long-term scarring or pigmentary alterations.⁶⁷ After three treatments at 4- to 6- week intervals, investigators rated a mean improvement of 26% to 50% for wrinkles, 51% to 75% for pigment, and 26% to 50% for texture, with subjects reporting similar results.

Pretreatment, a topical anesthetic such as bupivacaine/lidocaine/tetracaine anesthetic cream is applied for 30 minutes preoperatively.⁵³ After the removal of the cream, the area is treated with a nonsequential fractional CO₂ laser using 75-mJ, 100-Hz, and a 0.3-second repeat delay (Active FX, Lumenis Ltd., Yokneam, Israel). A computer pattern generator with settings of 3 pattern, 5 size, and 1 density (corresponding to less than 10% overlap) is used. After the procedure, cool sterile saline compresses and ointment are applied. In skin types III or greater, a class VI topical corticosteroid ointment is started daily for 5 days on postoperative day 2 to minimize the occurrence of postinflammatory pigmentary alteration. The use of fractionated ablative laser is generally not recommended in patients of skin types V and VI unless performed by a highly experienced laser surgeon (Fig. 80-10).

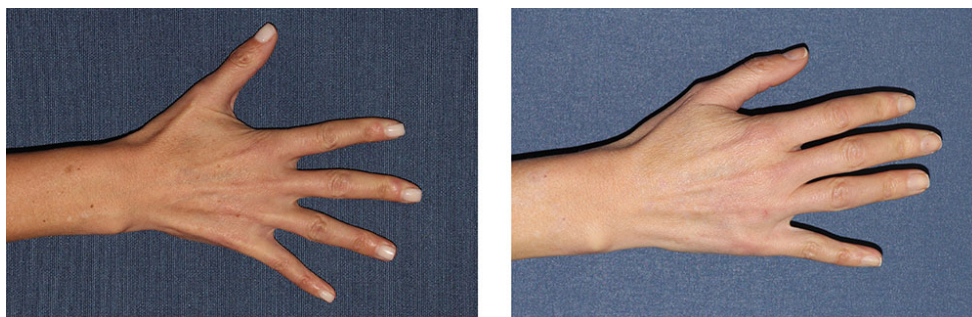


Figure 80-10. A 42-year-old female demonstrated scattered and few solar lentigines and macular seborrheic keratosis on the dorsal hand. One treatment of Q-switched alexandrite to the lesions resulted in complete clearance of the lesions. Before (left) and 7 weeks after (right) one treatment of Q-switched alexandrite.

RADIOFREQUENCY

RF uses an alternating electrical current to deliver energy to the skin. The purpose of RF devices used for minimally invasive cosmetic treatments of the face and body is to produce selective dermal injury, leading to a responsive wound repair while keeping the overlying epidermis intact.^{68,69} The electrical current heats the deep dermis, fat, fibrous septae, and (with internally applied monopolar RF devices) fascia. RF energy is not reflected or absorbed by epidermal melanin or vasculature as it passes through the skin, making it safer to use in all skin types. This volumetric heating of the dermis and subcutaneous fibrous septae is associated with collagen denaturation and subsequent thickening and shortening of the collagen fibers leading to increased fibroblast activity and new collagen formation resulting in skin tightening over 4 to 6 months. An advantage this technique employs over fractional lasers is a low risk of postinflammatory hyperpigmentation.⁷⁰

In a prospective, multicenter study using a monopolar RF device for moderate to severe hand wrinkles, 31 patients receiving 3 RF treatments at 2-week intervals showed a 50% improvement from baseline with no adverse effects reported.⁷¹ For the treatment, the RF device (Pelleve S5 Wrinkle Treatment Generator; Ellman International Inc., Oceanside, NY; 4.0 MHz, 120 W) with a 20-mm handpiece (GlideSafe; Ellman International Inc.) was set at a level of energy based on verbal feedback about tip warmth from the patient. The handpiece was moved in continuous overlapping corkscrew patterns to completely cover each of the three gel-coated treatment zones.

When the skin surface temperature of the treated areas reached 40° to 42°C, the treatment was continued for an additional 3 minutes. This sequence was then repeated for a total of 2 passes in each zone.

Microneedle fractional RF systems generate precise ovoid areas of coagulation in the dermis and subcutaneous tissue, bypassing the epidermis. The location of the thermal injury depends on needle depth and conduction times. The technology has been studied on the face and neck for skin rejuvenation and treatment of acne scars. While no studies have yet evaluate its use on the dorsal hands, keeping the intensity low and the depth of needle penetration shallow is advisable.

Chemical peels

The aged appearance of the hand can be improved with chemical peeling, though there are few reports in the literature. Much like the concerns noted for laser therapy, the reduced number of pilosebaceous units and decreased vasculature can often lead to impaired wound healing.⁵⁴ Chemical peels are classified as superficial, medium, or deep based on their depth of penetration into the epidermis and dermis. In general, a light or medium depth peel should be employed to minimize the risk of postprocedure complications. Swinehart employed a 50% salicylic acid paste for photoaging on the forearms and hands in a cohort of 11 patients.⁷² Maceration and desquamation followed, and recovery took up to 4 weeks. While rare, salicylism is a potential side effect when treating large areas. The process should be employed conservatively, and patients should be warned that numerous treatment sessions may be required before the gradual and mild improvement in skin texture is noticeable.

Superficial chemical peels penetrate to the level of the epidermis and include 70% glycolic acid, salicylic acid, 50% resorcinol, Jessner's solution, solid CO₂ slush, and 10% to 25% trichloroacetic acid (TCA) peel. Medium-depth peels penetrate through the papillary dermis and include TCA peels at concentrations greater than 30%. The results of the chemical peels vary greatly, and are dependent on the concentration, contact time, and the manner in which the skin is prepared. Though more likely with deeper peels, all chemical peels confer a risk of dyschromia, prolonged erythema, a discrete line at the treatment border of the arm and hand, and scarring. Cox

reported the development of multiple keratoacanthomas following a 70% glycolic acid gel and 40% TCA chemical peel to the forearms.⁷³

Combination treatments for hand rejuvenation

Patients who exhibit more than one sign of aging often require several therapeutic modalities, some of which can be completed on the same day. Sclerotherapy and autologous fat transfer are should be performed separately. When combining treatments on the same day, start with modalities that target the epidermis and dermis, followed by those that remedy volume loss.

For patients with extrinsic sings of aging (pigmentation, vascular lesions, actinic keratosis), various energy devices can be used. For those with mild pigmentation and photoaging, the entire dorsal hand can be treated with IPL followed by a QS or picosecond 755- or 1,064-nm laser to individual solar lentigines or seborrheic keratoses. For skin types IV to VI, IPL can be substituted by the 1,927-nm diode laser (Clear + Brilliant Perm  a). If the degree of photodamage is more severe, one can perform a fractionated 1,550-nm or fractionated CO₂ laser treatment after the use of a QS or picosecond pigment laser for individual lentigines and keratoses.

PDT can be used in patients with photodamage and actinic keratoses. Subsequent to epidermal and dermal procedures, the filler of choice can be injected to address skin laxity, volume loss, and the visibility of tendons, bones, and veins. Some physicians may use RF instead of fillers for patients with skin laxity and volume loss.

CONCLUSIONS

Hand rejuvenation is becoming increasingly popular as both patients and physicians appreciate its aesthetic impact. Most procedures require minimal downtime and produce excellent aesthetic results. Dermal fillers minimize the prominence of tendons, bones, and veins, while improving the appearance of skin laxity. Sclerotherapy and endovenous laser ablation can minimize the appearance of dorsal hand veins. Chemical peels, IPL, QS and picosecond lasers, as well as both nonablative and ablative lasers can improve dyschromia and skin texture. A multi-modality approach to treat the

multiple causes of visible hand aging is often necessary, and most procedures may be performed sequentially on the same day or spaced over multiple treatment visits.⁷⁴

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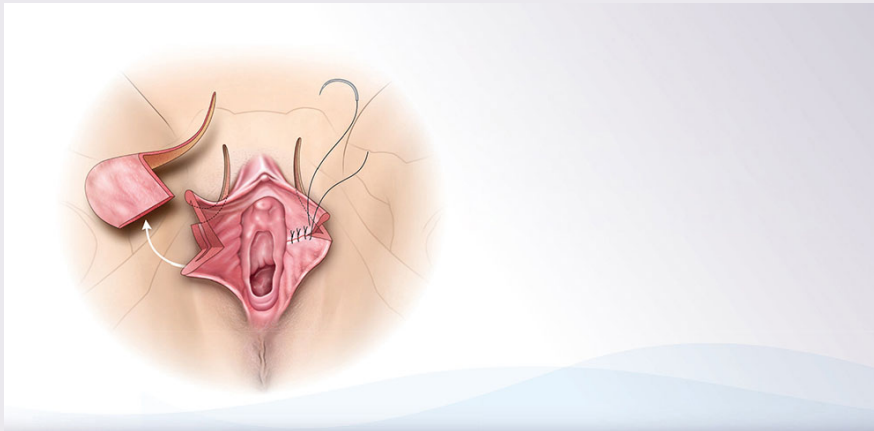
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CHAPTER 81 Approaches to Female Genital Rejuvenation

Christine A. Hamori



SUMMARY

- The popularity of vaginal rejuvenation has increased dramatically over the past decade.
- Several trends are responsible for this surge in interest, including the Internet and significant changes in grooming habits, as well as improvement in surgical techniques.
- There is a bimodal age distribution of women seeking vaginal rejuvenation with peaks in both the fourth and sixth decades.

Beginner Tips



- A thorough and comprehensive understanding of vulvar anatomy is a prerequisite for considering female genital rejuvenation.
- A full perineal evaluation should be performed when labia minora reduction is requested.
- Baseline photography, both standing and in lithotomy, is very helpful.
- Noninvasive treatments, such as ablative and nonablative fractional laser treatments, are increasing in popularity.

Expert Tips



- Labiaplasty may be combined with fat grafting and laser resurfacing to provide an optimal outcome in the appropriate patient.
- Treatment of the labia majora should be done with caution, as scars tend to be significantly more visible than those associated with labia minora reduction.
- Thin labia minora are less amenable to wedge resection.
- Patients with large clitoral hoods are better treated with an extended wedge technique, rather than an edge trim.

Don't Forget!



- Atrophic labia majora may contribute significantly to the appearance of labia minora redundancy.
- While still controversial, the net effect of labiaplasty in the absence of complications is an improvement in sensation.

Pitfalls and Cautions



- A common complication of inadequate closure of the wedge defect is a window, or mid incisional partial dehiscence.
- Repair of the defect is difficult, as the temptation exists to re-excise the wedge, which frequently results in a secondary dehiscence.

Patient Education Points



- Controlling patient expectations is critical.

- Review the patient's anatomy with a mirror in the standing and lithotomy positions to make sure that their expectations are realistic.
- Recovery is often extensive, and patients should understand that they will need a lengthy period of pelvic rest.

CHAPTER 81 Approaches to Female Genital Rejuvenation

INTRODUCTION

Vaginal rejuvenation, or aesthetic female genital surgery, includes myriad cosmetic procedures designed to improve the appearance of the female external genitalia, including the mons pubis, labia majora, labia minora, and the clitoral hood. Historically, such procedures date back to ancient Egypt, where enhancement of the vulva with adornments, bleaching and reductive techniques were described.¹ It is a distinct and separate entity from female genital mutilation, or the complete removal of the labia minora, clitoral complex, and labia majora, which is practised in some Islamic and Arabic countries.

HISTORY

Modern surgical techniques for reduction of the labia minora were first described in the 1970s and 1980s,^{2,3} and most techniques represented variations of trimming the distal edge of the labia minora. It was not until 1998 that Gary Alter, a plastic surgeon and urologist, described a modified wedge procedure for labia minora reduction in response to undesirable complications such as irregular scar deformities and decreased labia minora sensitivity. The wedge technique preserves the natural edge contour and pigmentation of the labia minora.⁴

There has been an exponential increase in the demand for aesthetic female genital surgery over the past decades. Plastic surgery statistics in the United States show continued double-digit percentage increases in labiaplasty procedures since 2007, with a 400% increase between 2011 and 2015.⁵ More than 8,700 labiaplasties were performed in 2015 by plastic surgeons alone, and actual national numbers are much higher as many procedures are performed by gynecologists, urologists, and dermatologic surgeons as well.

The increased popularity of aesthetic vaginal procedures can be attributed to several factors including a change in pubic hair grooming habits (less hair leading to more visibility of the underlying anatomy);⁶ media portrayal of a prepubescent vulvar appearance as the norm; and the rise of the Internet as an anonymous resource for women to explore options in vaginal rejuvenation.

Motivational factors are based on a combination of appearance and functional discomfort. A recent study from the Netherlands found emotional discomfort regarding self-appearance in social and sexual relationships to be the most prevalent motivation for women considering labial reduction surgery on online communities, regardless of age and national background. Functional discomfort (chafing and invagination during intercourse) ranked second among reasons women seek labiaplasty.⁷

APPROACH TO THE GENITAL REJUVENATION PATIENT

Women with concerns about the appearance of their genitalia tend to first explore treatment options anonymously on the Internet. Once they understand that labiaplasty may be a viable option, they either consult with a dermatologic or plastic surgeon or their gynecologist. Gynecologists, however, frequently dismiss cosmetic concerns and tend to dissuade patients from pursuing procedures to alter the natural labial anatomy. In 2007, the American College of Obstetrics and Gynecology (ACOG) published a position statement regarding aesthetic genital surgery,⁸ condemning aesthetic genital surgery due to a lack of scientific evidence of its efficacy and safety. In 2016, ACOG published guidelines for gynecologists inundated by requests of adolescent patients for labiaplasty.⁹ Recommendations were made to encourage nonsurgical options (lubricants, tucking, clothing modifications)

and avoid surgical intervention. If young patients fail conservative measures, only then should they be referred to an appropriate surgeon for labiaplasty.

Women seeking improvement in the vulvar appearance are frequently embarrassed to discuss the issue with their primary care provider, and use sociomedical forums to explore treatment options. Pragmatically, an Internet presence and an informative website with before and after pictures are important in attracting potential labiaplasty patients. This population of patients relies heavily on peer references (physician reviews) in seeking out a surgeon trained in vaginal rejuvenation.

The two most common subsets of patients that present for labiaplasty are women in their 30s and perimenopausal women in their 50s. The younger patients represent the largest group, and complain of discomfort (chafing) with physical activities such as biking or horseback riding. Additionally, they report difficulty wearing yoga pants due to excess labial tissue or “camel toe.” Women in their 50s note laxity of the labia minora worsened by childbirth and menopause.

In consulting with labiaplasty patients, it is important to understand the patient’s motivation for seeking out surgery. Patients often desire an improved vulvar appearance. Approximately one-third of women seeking labiaplasty have been teased or had derogatory comments made about their genital appearance.¹⁰ A thorough social history is important to uncover any evidence of sexual dysfunction.

Physical examination should be performed with a proctor in the room. Patients should be examined in the standing and lithotomy positions. Most examination tables have stirrups, though if they are not available the frog-legged position may be utilized. A handheld mirror should be given to the patient during the examination so that she can point out specifically what is bothersome. The entire vulva is evaluated beginning with the appearance of the mons pubis, labia majora, minora, clitoral hood, posterior fourchette, and anus. A speculum examination is not routinely performed for aesthetic cases.

Labia majora skin quality, elasticity, and fatty content should be documented. Many patients have very atrophic labia majora that contribute to the perceived minora redundancy. In the standing position, patients usually demonstrate the desired postoperative appearance by retracting the labia minora posteriorly from behind the buttock with their hand. It is important to explain to patients that such a degree of “tucking” of the minora is rarely achieved.

In general, aesthetic genital surgery patients are realistic in their expectations though there are several red flags, including the patient who insists on a specific technique based on their “research”; patients with small labia minora with little obvious cosmetic deformity; patients who refuse to view the area with a mirror; and patients that do not grasp the potential risks and complications of the procedure.

Anatomy

The basic anatomy of the female vulva consists of the mons pubis, the labia majora, and the labia minora. The clitoris superiorly is located under a hood or prepuce that splits to join the labia minora on either side of the introitus. (Fig. 81-1). Beneath the apex of the frenulum the urethral meatus can be found. The labia minora converge posteriorly beyond the vaginal opening to form the posterior fourchette, or remain separated as they attach to the perineum.

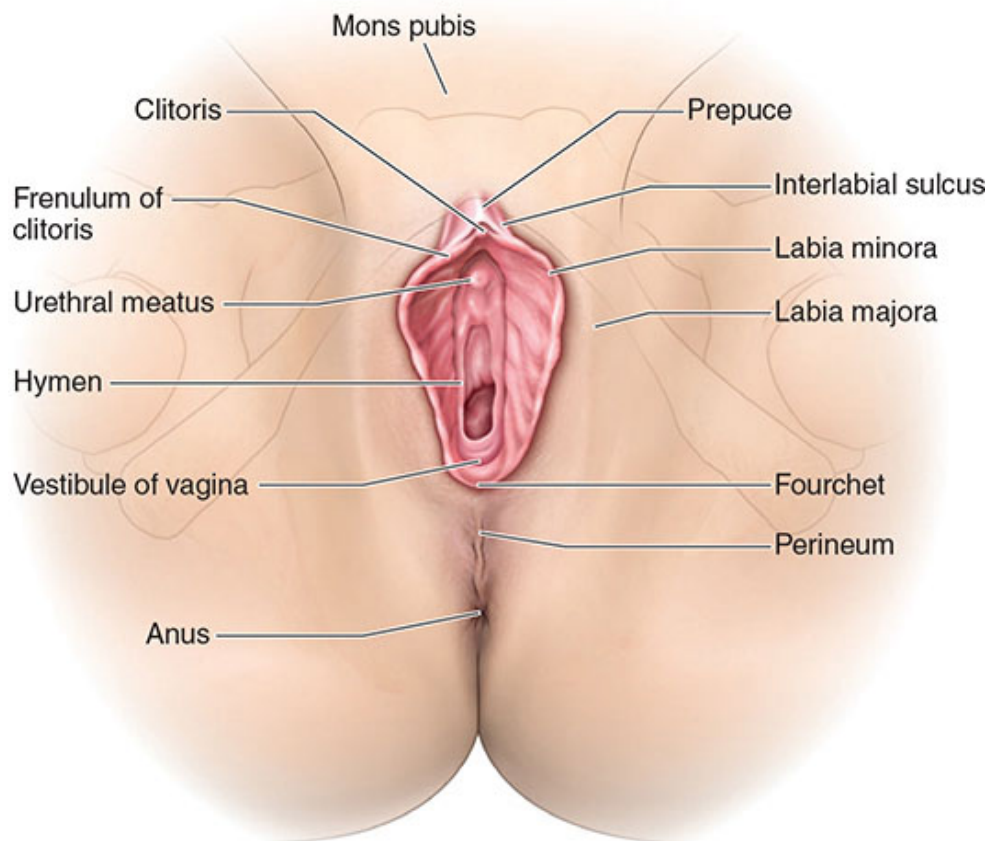


Figure 81-1. Anatomy of the external female genitalia.

The labia minora themselves lack hair follicles and subcutaneous fat, unlike the labia majora. Measurements of the length of the minora range from 2 to 10 cm.^{11,12} Due to wide anatomical variation of labia minora size and shape, it is difficult to define true labial hypertrophy. In a review of 163 labiaplasties, Rouzier et al. designated labial hypertrophy if the distance from the base to the edge is greater than 4 cm.¹³ Most women who request labiaplasty dislike the protrusion of the labia minora beyond the labia majora in the standing position.¹⁴ Since minora protrusion is dependent upon labial length, shape, and coverage by the labia majora, measurement of labial length alone is not a useful parameter in planning labiaplasty.

The blood supply to the vulva is derived primarily from the external and internal pudendal systems, as well as smaller contributions anteriorly from the obturator and funicular arteries. In 2015, Georgiou et al. defined the arterial supply of the labia minora in 10 cadaveric specimens using contrast CT and rotational angiography.¹⁵ They described the central artery extending from the base of the labia to the tip to be the dominant arterial supply to the labia minora. This artery located just deep to the mucosa is supplied primarily by the internal pudendal system posteriorly. A small anterior branch from the external pudendal system was present as the secondary feeder to the central artery (Fig. 81-2).

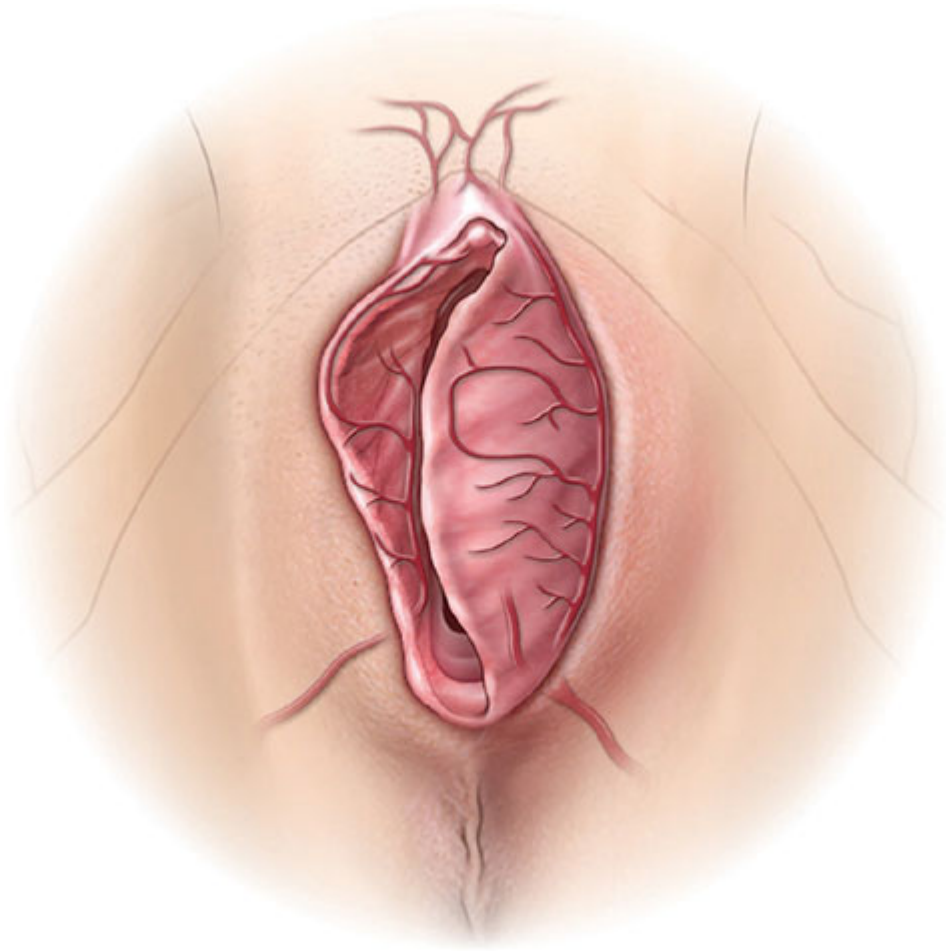


Figure 81-2. The blood supply to the vulva is derived primarily from the external and internal pudendal systems, as well as smaller contributions anteriorly from the obturator and funicular arteries.

The nerve supply to the vulva consists of the genital branch of the genitofemoral nerve, the ilioinguinal nerve, the pudendal branch of the posterior femoral cutaneous nerve and the inferior hemorrhoidal nerve (Fig. 81-3). The dorsal nerve of the clitoris is analogous to the dorsal nerve of the penis and is a terminal branch of the pudendal nerve. It courses along the ischiopubic ramus and anteriorly pierces the perineal membrane to supply the clitoris. Due to its deep location, injury to this nerve is unlikely during labial surgery. Superficially, genital corpuscles are rapidly adapting mechanoreceptors present in the labia minora, clitoral hood, clitoris, and the vaginal vestibule. These microscopic coils of nerves are highly sensitive to touch and vibration.

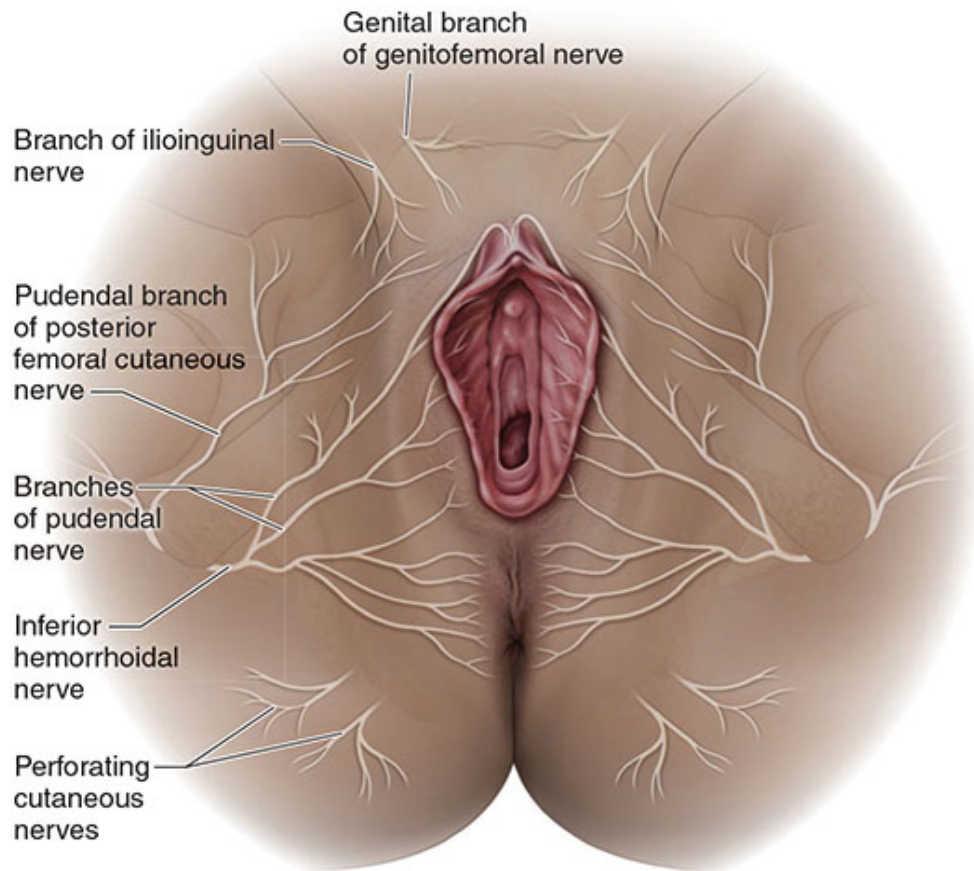


Figure 81-3. The nerve supply to the vulva consists of the genital branch of the genitofemoral nerve, the ilioinguinal nerve, the pudendal branch of the posterior femoral cutaneous nerve and the inferior hemorrhoidal nerve.

Controversy exists regarding the potential reduction of labial and or clitoral sensation after labiaplasty. Despite the documented high satisfaction rate postoperatively in both sexual satisfaction and emotional well-being,¹⁶ doubts exist regarding the potential for nerve injury or decreased sensation. Recently, this theory has been refuted. A recent cadaveric study demonstrated that the nerve density of the labia minora is heterogeneous.¹⁷ Additionally, Placik et al. showed that sensation to light touch was maintained and actually improved after labiaplasty and clitoral hood reduction.¹⁸ Surgical procedures to alter the vulva can therefore safely be performed by trained surgeons familiar with the anatomy.

LABIAPLASTY PROCEDURES

Labia Minora

Photography and Preparation

The patient is photographed in front of a solid background with an anterior–posterior orientation in the standing position with legs spread slightly. This standing photograph helps document the degree of protrusion beyond the labia majora, the size and position of the labia majora, and any asymmetry that may be present.

A topical anesthetic may be applied to the area for 15 to 30 minutes. The patient is then brought into the operating room and placed in the lithotomy position with legs secured in boot-type stirrups to provide calf and foot support.

One dose of a second-generation cephalosporin antibiotic is given preoperatively either orally or intravenously. Once the patient is positioned, photographs are taken in the lithotomy position. The labia minora are posed abducted and adducted to document anatomic variation. Common size variations and asymmetries include the length of the labia minora ([Fig. 81-4](#)), the presence of a double fold ([Fig. 81-5](#)), a wide clitoral hood, the presence of a posterior confluence of the labia minora, and a widened clitoral hood ([Fig. 81-6](#)). These variations merit special attention intraoperatively in order to achieve symmetry and avoid surgical revisions.



Figure 81-4. Labia minora asymmetry is a common concern.



Figure 81-5. A double fold is another cause for patient concern. Note the left labia minora double fold.



Figure 81-6. Some patients demonstrate the presence of a posterior confluence of the labia minora, and a widened clitoral hood.

Markings for wedge resection

Marking is performed prior to the injection of any local anesthetic. The wedge is centralized around the most prominent portion of the labia minora. It is best to keep the superior incision at or below the confluence of the clitoral frenulum and the labia minora. This will help in realigning the tissues after resection. The incision is drawn from the edge of the labia minora toward the introitus, stopping just proximal to Hart's line where the keratinized and nonkeratinized vestibular mucosae meet. The second limb of the wedge is estimated by folding redundant labia minora upon itself. The second marking extends from the apex of the first to the labial edge, creating a triangle of tissue to be resected. It is imperative that the edges of the labial defect approximate with minimal tension.

Markings for edge trim resection

Markings are made laterally on the labia minora starting below the frenulum toward the introitus. It is important to leave at least 1.5 cm of labia minora superiorly, as the upper third of the labia minora tends to retract the most after excision. The desired amount of labia minora protrusion past the labia majora is considered when continuing the marking toward the posterior fourchette. The medial side of the edge trim is then marked. Removal of slightly more medial labia minora while leaving slightly more lateral labia minora tissue will result in a more medially hidden scar.

Local injection

Once the markings are completed, 1% lidocaine with epinephrine 1:100,000 with sodium bicarbonate is injected using a 30-gauge needle submucosally along the markings. Slow injection is important to reduce discomfort. After the mucosal incisions have been anesthetized, the lateral labial incisions may be injected. It is important to allow at least 10 minutes for the anesthetic and epinephrine to take effect. During this time, a sterile prep is performed on the perineum. The markings should be retraced as they tend to fade once the prep is complete.

Resection

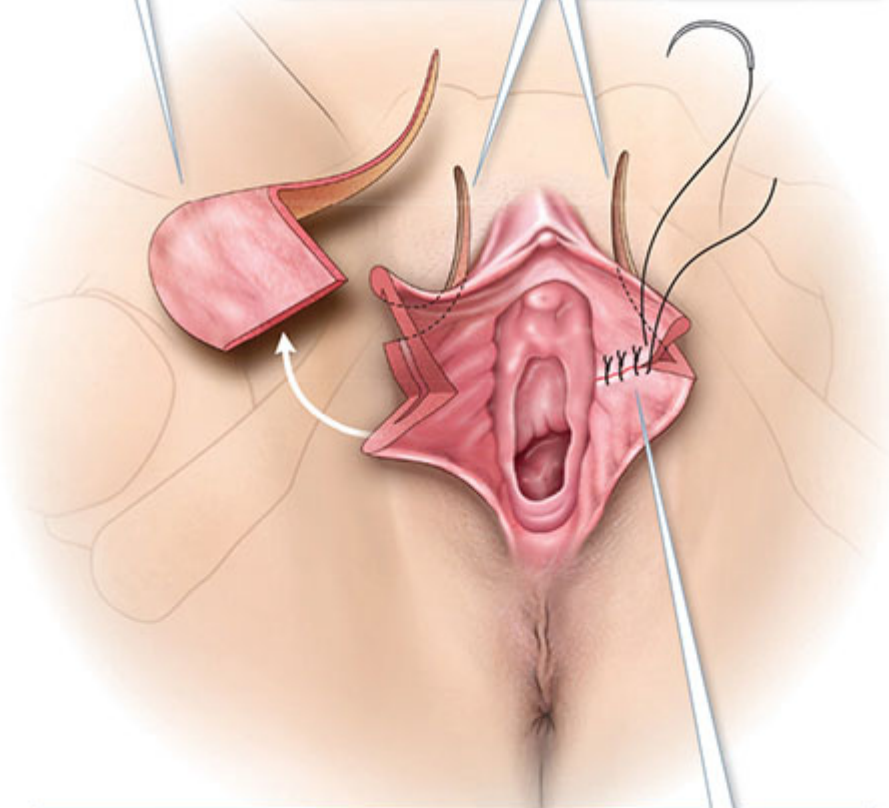
Incisions are made with a 15 blade, Peak Plasma blade (Medtronic), or a needlepoint standard radiofrequency (RF) cautery.¹⁹ Diode lasers have also been used to perform labiaplasty.²⁰

Wedge resection technique

The medial (mucosal) incision along the wedge marking is performed first (Fig. 81-7). Care is taken to keep the incision superficial to avoid damaging the central artery of the labia minora. The lateral incisions are then performed, completing the wedge. Thick or large labia minora warrant more submucosal resection to debulk and reduce their size. In patients with very atrophic, thin labia minora (Fig. 81-8), it is best to demucosalize the wedge rather than perform a full-thickness resection. The resection is performed starting medially at the apex of the wedge triangle along the vagina, extending laterally toward the labial free edge. Once the vaginal side is complete, the lateral apex is deepithelialized distally to the free edge of the labia minora. Hemostasis is obtained with cautery, and Marcaine 0.05% with 1:200,000 epinephrine may be injected along the base of the wound.

The wedge is centered around the most prominent portion of the labia minora, keeping the incision superficial to avoid damaging the central artery of the labia minora. The resection is performed starting medially at the apex of the wedge triangle along the vagina, extending laterally toward the labial free edge.

A lateral dog-ear is usually present with moderate to large wedge excisions, which is best corrected by removing tissue excess superolaterally along the clitoral hood.



The closure is performed in layered fashion beginning with the dermis of each edge on the vaginal side. Buried interrupted sutures are placed medially to laterally. The leading edge of the wedge defect may be closed with a vertical mattress suture to evert the edges and avoid notching.

Figure 81-7. The wedge resection technique is a fundamental approach to labiaplasty.



Figure 81-8. In patients with very atrophic, thin labia minora, it is best to demucosalize the wedge rather than perform a full-thickness resection.

The closure is performed in layers beginning with the dermis of each edge on the vaginal side. Buried interrupted sutures of 4-0 or 5-0 absorbable suture are placed medially to laterally. The leading edge of the wedge defect may be closed with a 5-0 monocryl vertical mattress suture to evert the edges and avoid notching. A lateral dog-ear is usually present with moderate to large wedge excisions. This is best corrected by removing the tissue excess superolaterally along the clitoral hood. This maneuver has the added benefit of narrowing the clitoral hood.²¹ Once the dog-ears have been resected, a running locking 5-0 vicryl rapide is sutured along the length of the incision (Fig. 81-9).

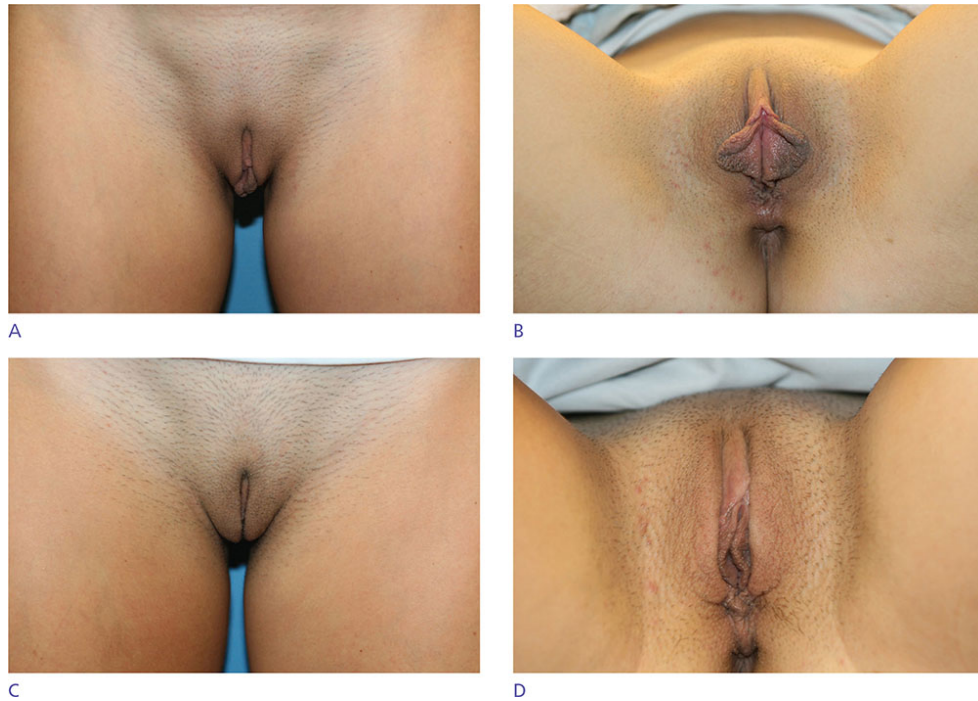


Figure 81-9. Wedge resection before (A and B) and after (C and D) photographs. Note the marked improvement in labial appearance.

Edge resection technique

The labia minora are gently extended laterally with the help of an assistant. Conservative markings for edge resection are performed on the labia, clitoral frenulum, and clitoral hood. The medial incision is made with the cutting mode of the cautery first, beveling downward toward the base of the labia minora. The lateral incision is then made beveling in the opposite direction to create a trench between the two incisions that will allow the edges to fall together with closure. The challenge of the edge trim is to create a smooth transition from the clitoral hood through its junction with the clitoral frenulum to the posterior labia minora. This is done by narrowing the width of the clitoral hood at the junction of the frenulum and the labia minora. Meticulous layered closure is performed with 5-0 monocryl buried interrupted dermal sutures followed by a running 5-0 vicryl rapide.

Aftercare

Once the incisions are closed, topical antibiotic ointment is applied followed by a disposable perineal pad and cold pack. The injected bupivacaine provides approximately 4 hours of analgesia after which the patients may experience some pain which manifests as burning or stinging. They are instructed to take narcotic pain medications every 4 to 6 hours as necessary for the next 24 to 48 hours. A peri bottle is given to the patient at discharge with instructions to spray warm water over the incisions after micturition. In patients over the age of 35, topical conjugated estrogen (Premarin) is prescribed, and may be applied to the area three times per week for 6 weeks. This may help with wound healing in women with vulvovaginal atrophy. An oral second-generation cephalosporin antibiotic is prescribed for 5 days.

Patients are instructed to rest for 3 to 4 days and attempt to elevate the pelvis as much as tolerated. They may apply moist cool packs to the area. Patients may shower on day 2 after surgery. It is important to avoid harsh soap during the healing period. Tight fitting pants and jeans are discouraged during the first few weeks to avoid disrupting the sutures. The first postoperative visit is on day 14, when the incisions are checked and external sutures are usually noted to be dissolving. Patients are then seen at 2 months postoperatively. At this point, most of swelling has diminished and patients are allowed to return to full exercise and sexual intercourse.

The basic surgical instrument set up for labiaplasty can be seen in [Figure 81-10](#).



Figure 81-10. Instrument setup for a labiaplasty technique.

Labia Majora

Women presenting for aesthetic genital surgery are most commonly concerned with labia minora protrusion.²² The labia majora, however, contribute to the appearance of the vulva as well. The desired aesthetic portrays a narrow inter labial cleft with minimal minora show (Fig. 81-1). The labia majora are suspended anteriorly by a full mons pubis. Weight loss can result in both a flattening of the mons (loss of anterior suspension) and a

deflation of the labia majora themselves (Fig. 81-2). The result is inferior displacement of the labia majora (sagging). This can be seen in massive weight loss patients and young women in their 20 who have lost a significant amount of weight, such as ballerinas or athletes.

Women in their 40s or 50s usually present with complaints of deflation, wrinkling and sagging of the labia majora. Most of these women have been pregnant, and therefore endured inflation and deflation of the mons and labia majora skin. Varicosities, common in pregnancy, may also occur in the perineum, further contributing to skin stretch. Hormonal redistribution of fat seen in middle age may also contribute to the labia majora fat loss seen in postmenopausal women. The redundant folds of labia majora can be seen in lithotomy position (Fig. 81-3).

Women with enlarged labia majora usually complain of bulkiness in their clothing, especially swimsuits. Treatment options for labia majora excess and/or deflation are based on the physical examination and desires of the patient. Excess labia majora skin is apparent in the standing position when the cleft between the labia majora appears long. This often gives the appearance of a “closed clam shell” or the lateral view of a “porpoise nose” (Fig. 81-4). Treatment is surgical reduction of the labia majora. Unlike labia minora reduction, the scars for labia majora reduction are quite visible. Patients should be shown scars from labia majora reduction as part of the informed consent discussion.

Labia majora reduction is usually performed via a lenticular excision of the medial portion of the redundant labia majora. It may be performed under local or general anesthesia. Patients are photographed in the standing and lithotomy positions. Once in the OR with the patient in lithotomy, the tissue excess is evaluated and the conservative lenticular resection of the labia majora is marked (Fig. 81-5). The medial incision should be placed at the junction of the hair-bearing labia majora and the smooth hairless groove between the majora and the minora. This will avoid carrying the hair-bearing labia majora skin too medially, where hair growth could irritate the lateral labia minora.

Lidocaine 1% with epinephrine is injected along the proposed incisions. The medial incision is incised first, and a lateral subcutaneous flap is elevated to just medial of the lateral marking. A coronal incision is then made bisecting the flap into two triangular flaps. The tension on closure should be tested as flap transection is performed. It is important to create a

tension free closure so that there will not be excess flattening of the majora, splaying of the labia minora, or scar hypertrophy. A towel clip or staple is used to temporarily attach the bisected flap to the outer incision margin. The two triangular flaps are then marked and resected. Prior to closure, the deep fat of the labia majora should be assessed and resected if warranted. Large blood vessels are found within the deep majora fat,²³ so meticulous hemostasis is necessary to avoid hematoma formation (Fig. 81-6).

Hemostasis is obtained with a cautery device, and 0.25% Marcaine may be injected intradermally for postoperative pain relief. Layered wound closure is performed with buried 4-0 monocryl sutures on an SH needle and a running 5-0 vicryl rapide on a cutting P-1 needle. Topical antibiotic ointment, an absorbent pad, and ice pack are applied.

Recovery requires elevation of the pelvis as much as possible to avoid swelling. Patients may apply ice and will require narcotic pain medicine for several days. Exercise is permitted after 3 weeks, and sexual intercourse after 5 to 6 weeks. Labia majora reduction may be combined with labia minora and/or clitoral hood reduction. Combined procedures will result in more edema and an extended recovery period.

SPECIAL CONSIDERATIONS

Certain anatomical variations warrant more attention than others when planning aesthetic genital surgery. With labia minora reduction, not only the length of the labia minora, but also the thickness of the subcutaneous and submucosal tissue should be assessed.

Thin labia minora (Fig. 81-11) are less amenable to wedge reduction techniques due to their thin dermis and submucosa, which make layered closure of the wedge defect difficult. A common complication of inadequate closure of the wedge defect is a window, or mid incisional partial dehiscence. Repair of the defect is difficult, as the temptation exists to reexcise the wedge, which frequently results in a secondary dehiscence. It is best to attempt to convert the closure of the window to an edge closure by excision of the distal labia minora on either side of the dehiscence to create a smooth external border at the level of the window. This may create a labium that is slightly shorter when compared to the contralateral side (Fig. 81-12).



Figure 81-11. A common complication of inadequate closure of the wedge defect is a window, or mid incisional partial dehiscence.



Figure 81-12. It is best to convert the closure of the window to an edge closure by excision of the distal labia minora on either side of the dehiscence to create a smooth external border at the level of the window. This may create a labium that is slightly shorter when compared to the contralateral side.

Another anatomical variation to be wary of is the large clitoral hood (Fig. 81-13). In evaluating patients with significant volume of the clitoral area it is important to palpate the clitoris to make sure that clitoromegaly is not the source of tissue excess. Once it is determined that only the clitoral hood is redundant and the clitoral size is normal, methods of clitoral hood reduction should be considered. Usually the width of the clitoral hood is the issue of concern. This should be treated with a lateral hood excision on either side or an extended labiaplasty, where the dog-ear from the wedge resection is taken anterolaterally to decrease the width of the clitoral hood.



Figure 81-13. Another anatomical variation to be wary of is the large clitoral hood.

Patients with large clitoral hoods are better treated with an extended wedge technique, rather than an edge trim. A large clitoral hood is tethered posteriorly during the closure of a wedge procedure. In contrast, when an aggressive edge trim is performed without addressing the clitoral hood, an imbalance occurs. Patients end up with a “penis deformity,” where the labia minora appear amputated and the clitoral hood paradoxically enlarged (Fig. 81-14). This is a very difficult problem to repair, and clitoral hood flaps may be needed to improve the appearance of these deformities.²⁴

In considering patients for wedge resection, it is important to evaluate the posterior portion of the labia minora or the posterior fourchette. There are two anatomic variations that exist: separate posterior labia minora (Fig. 81-15) or a connected posterior lip (Fig. 81-16). In the latter, wedge resection may pull the posterior connection anteriorly resulting in partial posterior obstruction of the introitus. Patients will complain of discomfort during intercourse. In order to prevent this problem, a modified episiotomy of the posterior lip should be performed at the time of the wedge resection. This will create two separate components of the labia minora and prevent any obstruction of the posterior introitus.



Figure 81-14. Patients may end up with a “penis deformity,” where the labia minora appear amputated and the clitoral hood paradoxically enlarged.



Figure 81-15. One variation is the separate posterior labia minora.



Figure 81-16. Another variation is a connected posterior lip.

COMPLICATIONS

The most common complication with labiaplasty is partial wound dehiscence or notch deformity.²⁵ This complication occurs more frequently with wedge resections (Fig. 81-17) than edge trim procedures. Smoking, diabetes, and obesity are risk factors for dehiscence. Additionally, patients who are too active in the early postoperative period may rupture a suture, resulting in an edge separation. Treatment of small edge dehiscence is either by reexcision with primary closure or edge trim of the remaining anterior and posterior sections. Prevention of wound separations is dependent on a tension free closure and meticulous surgical technique.

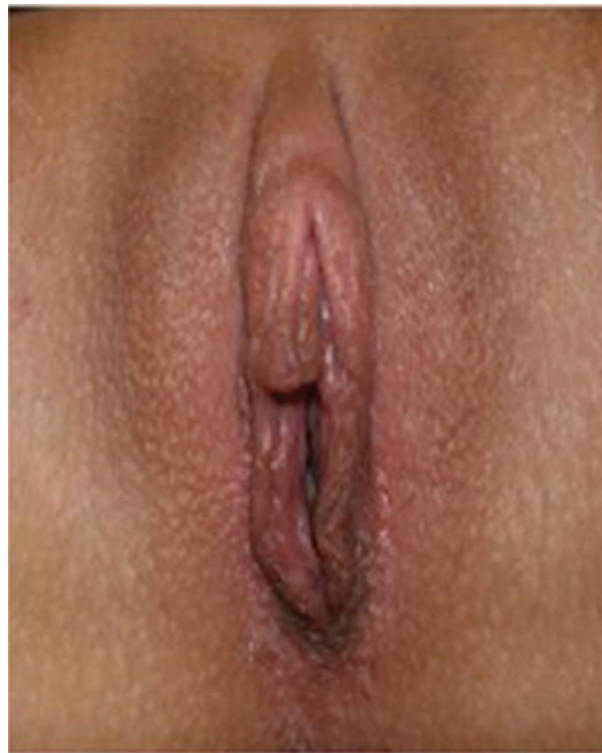


Figure 81-17. The most common complication with labiaplasty is partial wound dehiscence or notch deformity.

Hematoma is another complication that occurs with aesthetic genital surgery. Small hematomas with minimal tissue distortion and pain may be treated nonsurgically. Usually they liquefy in a few days and drain spontaneously from the incision (Fig. 81-18). Large hematomas are more common with labia majora reduction, and require operative evacuation and drainage (Fig. 81-19). Early intervention is important to avoid tissue

necrosis. Acceptable cosmetic results may be obtained after large hematoma drainage in most cases (Fig. 81-20).



Figure 81-18. Hematoma is another complication that occurs with aesthetic genital surgery.



Figure 81-19. Large hematomas are more common with labia majora reduction, and require operative evacuation and drainage.



Figure 81-20. Acceptable cosmetic results may be obtained after large hematoma drainage in most cases.

In general, complications from aesthetic genital surgery are uncommon. Proper attention to patient selection, careful preoperative planning, and meticulous surgical technique will help prevent most adverse events.

VOLUME AUGMENTATION OF THE MONS PUBIS AND LABIA MAJORA

Deflation of the mons pubis and labia majora is common with weight loss²⁶ and hormonal changes that occur with pregnancy and menopause. Since the desired aesthetic embodies a full, smooth, and hairless vulva, any contour irregularity such as wrinkling, flattening, and sagging is considered undesirable (Fig. 81-21). Patients rarely notice that the mons is smaller and less projected; rather, they complain of the flaccidity of the labia majora. In the lithotomy position, the volume loss or paucity of fat may appear as dents and puckers along the posterior one-third of the majora. Options for rejuvenation of this area include reduction of the skin envelope either surgically or noninvasively, and volume restoration with fat and fillers.



Figure 81-21. Deflation of the mons pubis and labia majora is common with weight loss and hormonal changes that occur with pregnancy and menopause and leads to wrinkling, flattening, and sagging.

The superficial layers of the labia majora consists of keratinized stratified squamous epithelium, dense dermis with varying numbers of melanocytes, a subcutaneous fatty layer rich in sebaceous glands and apocrine sweat glands, and a deep layer of smooth muscle (dartos). The subcutaneous fat is made up of a superficial and deep layer and extends across the perineum. The deep layer contains the Bartholin glands, the bulbospongiosus muscle over the vestibular bulbs, and the ischiocavernosus muscle overlying the corpora cavernosa.

When considering volume enhancement of the perineum, it is important to treat both the mons pubis as well as the labia majora. The mons projects forward in youth, tenting the labia majora anteriorly creating sagittal tension on the labia majora skin. With age and fat atrophy, the mons de-projects, and the labia majora lose their native volume, resulting in skin laxity in both the sagittal and coronal planes. This concept is well demonstrated in the massive weight loss patient (Fig. 81-22).



Figure 81-22. With age and fat atrophy, the mons de-projects, and the labia majora lose their native volume, resulting in skin laxity in both the sagittal and coronal planes. This concept is well demonstrated in the massive weight loss patient.

Volume enhancement of the mons and labia majora begins with an assessment of the soft-tissue envelope. If significant skin redundancy is present and excessive volume is injected, the labia majora become too large and bulky, which is not the aesthetic goal. Excessively filled labia majora are difficult to conceal in pants, and may give the appearance of “camel toe.” Skin excess of the majora may be addressed surgically with an elliptical sagittal excision as noted above. Alternatively, noninvasive tissue tightening by RF or fractional laser may be utilized to shrink the skin envelope.

Fat transfer is an excellent option for augmentation of the mons pubis and the labia majora.²⁷ The procedure may be performed in the frog-legged or lithotomy position to facilitate access to fat donor sites such as the abdomen, flank, and outer thighs. The average amount of fat needed for processing is approximately 150 cc. Depending on the amount of deflation, the mons may be injected with 10 to 20 cc of fat, and each majora 5 to 10 cc. Overfilling of the areas is usually necessary by 20% to 30% due to normal fat resorption. It is best to inject the mons pubis first to allow for elongation and elevation of the labia majora anteriorly. A 3-cc syringe may be used for the injection of the mons with a long 0.9-mm blunt side hole cannula. Access incisions are made with a 16-gauge needle from above. Once the volume is restored to the mons, the labia majora themselves are injected with fine cannulas (0.7-mm short blunt cannulas) using 1-cc syringes. Multiple passes are performed with small aliquots of fat injection with each pass. Labia majora port sites are made at the top and midway down the labia majora laterally. Conservative filling of the majora is important so as not to create excess bulk.

After the mons and labia majora are filled, the anterior-most portion of the labia majora at the junction with the mons is injected. Flattening and widening of the apex of the intervulvar cleft occurs with age (Figs. 81-23 and 81-24). A more youthful interlabial cleft can be created by fat grafting the medial superior labia majora at the junction with the mons pubis. Fat filling in this area and the labia majora conceals the clitoral hood and the labia minora, which is the desired youthful aesthetic.



Figure 81-23. Flattening and widening of the apex of the intervulvar cleft occurs with age.



Figure 81-24. Lengthening of the cleft is a common concern.

Case 81-1

Labiaplasty extended wedge technique: A 24-year-old female with labia minora hypertrophy presents for labiaplasty. Physical examination shows excess labia minora protrusion beyond the labia majora in the standing position. Lithotomy view reveals hyperpigmentation of the labia minora, thickening of the leading edge of the minora and mild asymmetry. Before and after pictures at 4 months postop are shown.



Labiaplasty extended wedge technique: A 46-year-old female presents with labia minora hypertrophy for labiaplasty. Physical examination shows asymmetrical protrusion of the mid labia minora beyond the majora in the standing position. Lithotomy position shows pigment along the distal edge of the minora, a bilateral double fold and asymmetry of the minora. Before and after pictures at 4 months are shown.

Fillers may be used in lieu of fat for volume enhancement of the labia majora. The advantage of fillers is that they are readily available and may be used in patients with minimal fatty donor sites. As of now, only one product, a highly cross-linked hyaluronic acid mixed with mannitol, has been developed specifically for vulvar use (Desirial Plus, Laboratoires Vivacy, Archamps, France). This product currently has CE approval in Europe for volume enhancement and the treatment of vulvovaginal atrophy.

The technique for injection of hyaluronic acid requires the patient to be marked in the standing position and then injected in the lithotomy position. Local anaesthesia is injected in small wheals for cannula access as with fat injection. Additional local anaesthesia should be injected along the path of the filler placement to reduce discomfort with filler injections. The depth of infiltration is into the deep dermis and subcutaneous fat. Optimal filler volumes are less than those with fat, as the hyaluronic acid will hydrate with time, though at least two to four syringes of product are required in cases of moderate fat atrophy.

Noninvasive vaginal rejuvenation

Over the past several years there has been an explosion of minimally invasive technologies for the improvement of both the appearance and function of the female genitalia. Many women are affected by stress urinary incontinence, sexual dysfunction, vaginal dryness, and vaginal laxity or dislike the appearance of the vaginal area. The same modalities that have been used for years to rejuvenate the face are now available for vulvar and intravaginal rejuvenation. RF²⁸ and ablative fractional lasers show promise in the reduction of stress urinary incontinence,²⁹ improvement of lubrication, enhanced orgasm,³⁰ and overall female sexual satisfaction.

Case 81-3

Fat grafting of the labia majora: A 47-year-old female presents with thinning of the labia majora for fat grafting. Physical examination shows fat atrophy of the mons pubis and labia majora in both the standing and lithotomy positions. Before and after pictures taken at 4 months after 40 cc fat grafting to the mons pubis and labia majora.



The proposed mechanism for vaginal and urethral changes seems to be excess collagen production in response to thermal injury. Histological studies have shown an increase in organized collagen fibrils as well as an increase in blood vessel numbers in vaginal specimens after treatment with these devices. At this time, however, most clinical studies have been based on subjective pre- and postoperative questionnaires given to patients before and after the procedures. Clinical outcome studies are underway to further assess the efficacy of laser and RF vaginal therapy.

CONCLUSIONS

Female aesthetic genital surgery has increased significantly over the past 10 years. Women of all ages show interest in improving the appearance of their genitalia. The popularity of Brazilian waxing and the availability of the Internet as an anonymous source for research have contributed to the exponential growth of the field.

Many publications in both the plastic surgery and gynecology literature exist with informative descriptions of surgical techniques to address labia minora excess. The two most common labiaplasty techniques are wedge reduction and edge trim. Physical examination and surgeon experience should

determine the most appropriate approach to labia minora reduction. Outcome studies have shown a low complication rate and high patient satisfaction postoperatively.

Other areas of the vulva may be considered for cosmetic rejuvenation as well. Patients may complain of excess skin or fat of the labia majora. Surgical reduction of the labia majora or noninvasive laser or RF procedures may result in significant cosmetic improvement of the vulvar region.

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